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THE COMING OF AGE OF THE ORIGIN OF SPECIES[1]

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MANY of you will be familiar with the aspect of this small, green-covered book. It is a copy of the first edition of the "Origin of Species," and bears the date of its production—the 1st of October, 1859. Only a few months, therefore, are needed to complete the full tale of twenty-one years since its birthday.

Those whose memories carry them back to this time will remember that the infant was remarkably lively, and that a great number of excellent persons mistook its manifestations of a vigorous individuality for mere naughtiness; in fact, there was a very pretty turmoil about its cradle. My recollections of the period are particularly vivid; for, having conceived a tender affection for a child of what appeared to me to be such remarkable promise, I acted for some time in the capacity of a sort of under-nurse, and thus came in for my share of the storms which threatened even the very life of the young creature. For some years it was undoubtedly warm work, but, considering how exceedingly unpleasant the apparition of the new-comer must have been to those who did not fall in love with him at first sight, I think it is to the credit of our age that the war was not fiercer, and that the more bitter and unscrupulous forms of opposition died away as soon as they did.

I speak of this period as of something past and gone, possessing merely an historical, I had almost said an antiquarian interest. For, during the second decade of the existence of the "Origin of Species," opposition, though by no means dead, assumed a different aspect. On the part of all those who had any reason to respect them-

[1] A lecture delivered at the Royal Institution, Friday, March 19, 1880, and printed in the July, 1880, issue of THE POPULAR SCIENCE MONTHLY, the editorial predecessor of THE SCIENTIFIC MONTHLY.

selves, it assumed a thoroughly respectful character. By this time the dullest began to perceive that the child was not likely to perish of any congenital weakness or infantile disorder, but was growing into a stalwart personage, upon whom mere goody scoldings and threatenings with the birch-rod were quite thrown away.

In fact, those who have watched the progress of science within the last ten years will bear me out to the full when I assert that there is no field of biological inquiry in which the influence of the "Origin of Species" is not traceable; the foremost men of science in every country are either avowed champions of its leading doctrines, or at any rate abstain from opposing them; a host of young and ardent investigators seek for and find inspiration and guidance in Mr. Darwin's great work; and the general doctrine of evolution, to one side of which it gives expression, finds in the phenomena of biology a firm base of operations whence it may conduct its conquest of the whole realm of nature.

History warns us, however, that it is the customary fate of new truths to begin as heresies and to end as superstitions; and, as matters now stand, it is hardly rash to anticipate that, in another twenty years, the new generation, educated under the influences of the present day, will be in danger of accepting the main doctrines of the "Origin of Species" with as little reflection, and it may be with as little justification, as so many of our contemporaries, twenty years ago, rejected them.

Against any such a consummation let us all devoutly pray; for the scientific spirit is of more value than its products, and irrationally-held truths may be more harmful than reasoned errors. Now, the essence of the scientific spirit is criticism. It tells us that, to whatever doctrine claiming our assent, we should reply, Take it if you can compel it. The struggle for existence holds as much in the intellectual as in the physical world. A theory is a species of thinking, and its right to exist is coextensive with its power of resisting extinction by its rivals.

From this point of view it appears to me that it would be but a poor way of celebrating the Coming of Age of the Origin of Species were I merely to dwell upon the facts, undoubted and remarkable as they are, of its far-reaching influence and of the great following of ardent disciples who are occupied in spreading and developing its doctrines. Mere insanities and inanities have before now swollen to portentous size in the course of twenty years. Let us rather ask this prodigious change in opinion to justify itself; let us inquire whether anything has happened since 1859 which will explain, on rational grounds, why so many are worshiping that which they burned, and

burning that which they worshiped. It is only in this way that we shall acquire the means of judging whether the movement we have witnessed is a mere eddy of fashion, or truly one with the irreversible current of intellectual progress, and, like it, safe from retrogressive reaction.

Every belief is the product of two factors: the first is the state of the mind to which the evidence in favor of that belief is presented; and the second is the logical cogency of the evidence itself. In both these respects the history of biological science during the last twenty years appears to me to afford an ample explanation of the change which has taken place; and a brief consideration of the salient events of that history will enable us to understand why, if the "Origin of Species" appeared now, it would meet with a very different reception from that which greeted it in 1859.

One-and-twenty years ago, in spite of the work commenced by Hutton and continued with rare skill and patience by Lyell, the dominant view of the past history of the earth was catastrophic. Great and sudden physical revolutions, wholesale creations and extinctions of living beings, were the ordinary machinery of the geological epic brought into fashion by the misapplied genius of Cuvier. It was gravely maintained and taught that the end of every geological epoch was signalized by a cataclysm, by which every living being on the globe was swept away, to be replaced by a brand-new creation when the world returned to quiescence. A scheme of nature which appeared to be modeled on the likeness of a succession of rubbers of whist, at the end of each of which the players upset the table and called for a new pack, did not seem to shock anybody.

I may be wrong, but I doubt if at the present time there is a single responsible representative of these opinions left. The progress of scientific geology has elevated the fundamental principle of uniformitarianism, that the explanation of the past is to be sought in the study of the present, into the position of an axiom; and the wild speculations of the catastrophists, to which we all listened with respect a quarter of a century ago, would hardly find a single patient hearer at the present day. No physical geologist now dreams of seeking outside the ranges of known natural causes for the explanation of anything that happened millions of years ago, any more than he would be guilty of the like absurdity in regard to current events.

The effect of this change of opinion upon biological speculation is obvious. For, if there have been no periodical general physical catastrophes, what brought about the assumed general extinctions and recreations of life which are the corresponding biological catastrophes? And if no such interruptions of the ordinary course of

nature have taken place in the organic, any more than in the inorganic, world, what alternative is there to the admission of evolution?

The doctrine of evolution in biology is the necessary result of the logical application of the principles of uniformitarianism to the phenomena of life. Darwin is the natural successor of Hutton and Lyell, and the "Origin of Species" the natural sequence of the "Principles of Geology."

The fundamental doctrine of the "Origin of Species," as of all forms of the theory of evolution applied to biology, is "that the innumerable species, genera and families of organic beings with which the world it peopled have all descended, each within its own class or group, from common parents, and have all been modified in the course of descent.[2]

And, in view of the facts of geology, it follows that all living animals and plants "are the lineal descendants of those which lived long before the Silurian epoch."[3]

It is an obvious consequence of this theory of Descent with Modification, as it is sometimes called, that all plants and animals, however different they may now be, must, at one time or other, have been connected by direct or indirect intermediate gradations, and that the appearance of isolation presented by various groups of organic beings must be unreal.

No part of Mr. Darwin's work ran more directly counter to the prepossessions of naturalists twenty years ago than this. And such prepossessions were very excusable, for there was undoubtedly a great deal to be said, at that time, in favor of the fixity of species and of the existence of great breaks, which there was no obvious or probable means of filling up, between various groups of organic beings.

For various reasons, scientific and unscientific, much had been made of the hiatus between man and the rest of the higher mammalia, and it is no wonder that issue was first joined on this part of the controversy. I have no wish to revive past and happily forgotten controversies, but I must state the simple fact that the distinctions in cerebral and other characters, which were so hotly affirmed to separate man from all other animals in 1860, have all been demonstrated to be non-existent, and that the contrary doctrine is now universally accepted and taught.

But there were other cases in which the wide structural gaps asserted to exist between one group of animals and another were by no means fictitious; and, when such structural breaks were real Mr.

[2] "Origin of Species," first edition, p. 457.

[3] "Origin of Species," first edition, p. 458.

Darwin could account for them only by supposing that the intermediate forms which once existed had become extinct. In a remarkable passage he says: "We may thus account even for the distinctness of whole classes from each other—for instance, of birds from all vertebrate animals—by the belief that many animal forms of life have been utterly lost, through which the early progenitors of birds were connected with the early progenitors of the other vertebrate classes."[4]

Adverse criticism made merry over such suggestions as these. Of course it was easy to get out of the difficulty by supposing extinction; but, where was the slightest evidence that such intermediate forms between birds and reptiles as the hypothesis required ever existed? And then probably followed a tirade upon this terrible forsaking of the paths of "Baconian induction."

But the progress of knowledge has justified Mr. Darwin to an extent which could hardly have been anticipated. In 1862 the specimen of *Archæopteryx*, which until the last two or three years has remained unique, was discovered; and it is an animal which, in its feathers and the greater part of its organization, is a veritable bird, while, in other parts, it is as distinctly reptilian.

In 1868 I had the honor of bringing under your notice, in this theater, the results of investigations made, up to that time, into the anatomical characters of certain ancient reptiles, which showed the nature of the modifications in virtue of which the type of the quadrupedal reptile passed into that of the bipedal bird; and abundant confirmatory evidence of the justice of the conclusions which I then laid before you has since come to light.

In 1875 the discovery of the toothed birds of the cretaceous formation in North America, by Professor Marsh, completed the series of transitional forms between birds and reptiles, and removed Mr. Darwin's proposition, that "many animal forms of life have been utterly lost, through which the early progenitors of birds were formerly connected with the early progenitors of the other vertebrate classes," from the region of hypothesis to that of demonstrable fact.

In 1859 there appeared to be a very sharp and clear hiatus between vertebrated and invertebrated animals, not only in their structure, but what was more important, in their development. I do not think that we even yet know the precise links of connection between the two; but the investigations of Kowalewsky and others upon the development of *Amphioxus* and of the *Tunicata* prove beyond a doubt that the differences which were supposed to constitute a barrier between the two are non-existent. There is no longer

[4] *Ibid.*, p. 431.

any difficulty in understanding how the vertebrate type may have arisen from the invertebrate, though the full proof of the manner in which the transition was actually effected may still be lacking.

Again, in 1859 there appeared to be a no less sharp separation between the two great groups of flowering and flowerless plants. It is only subsequently that the series of remarkable investigations inaugurated by Hofmeister has brought to light the extraordinary and altogether unexpected modifications of the reproductive apparatus in the *Lycopodiaceae*, the *Rhizocarpeae*, and the *Gymnospermeae*, by which the ferns and the mosses are gradually connected with the Phanerogamic division of the vegetable world.

So, again, it is only since 1859 that we have acquired that wealth of knowledge of the lowest forms of life which demonstrates the futility of any attempt to separate the lowest plants from the lowest animals, and shows that the two kingdoms of living nature have a common border-land which belongs to both or to neither.

Thus it will be observed that the whole tendency of biological investigation since 1859 has been in the direction of removing the difficulties which the apparent breaks in the series created at that time; and the recognition of gradation is the first step toward the acceptance of evolution.

As another great factor in bringing about the change of opinion which has taken place among naturalists, I count the astonishing progress which has been made in the study of embryology. Twenty years ago, not only were we devoid of any accurate knowledge of the mode of development of many groups of animals and plants, but the methods of investigation were rude and imperfect. At the present time there is no important group of organic beings the development of which has not been carefully studied, and the modern methods of hardening and section-making enable the embryologist to determine the nature of the process in each case, with a degree of minuteness and accuracy which is truly astonishing to those whose memories carry them back to the beginnings of modern histology. And the results of these embryological investigations are in complete harmony with the requirements of the doctrine of evolution. The first beginnings of all the higher forms of animal life are similar, and, however diverse their adult conditions, they start from a common foundation. Moreover, the process of development of the animal or the plant from its primary egg or germ is a true process of evolution—a progress from almost formless to more or less highly organized matter, in virtue of the properties inherent in that matter.

To those who are familiar with the process of development all *a priori* objections to the doctrine of biological evolution appear

childish. Any one who has watched the gradual formation of a complicated animal from the protoplasmic mass which constitutes the essential element of a frog's or a hen's egg has had under his eyes sufficient evidence that a similar evolution of the animal world from the like foundation is, at any rate, possible.

Yet another product of investigation has largely contributed to the removal of the objections to the doctrine of evolution current in 1859. It is the proof afforded by successive discoveries that Mr. Darwin did not over-estimate the imperfection of the geological record. No more striking illustration of this is needed than a comparison of our knowledge of the mammalian fauna of the Tertiary epoch in 1859 with its present condition. M. Gaudry's researches on the fossils of Pikermi were published in 1868, those of Messrs. Leidy, Marsh and Cope on the fossils of the Western Territories of America have appeared almost wholly since 1870; those of M. Filhol, on the phosphorites of Quercy, in 1878. The general effect of these investigations has been to introduce us to a multitude of extinct animals, the existence of which was previously hardly suspected; just as if zoologists were to become acquainted with a country, hitherto unknown, as rich in novel forms of life as Brazil or South Africa once was to Europeans. Indeed, the fossil fauna of the Western Territories of America bids fair to exceed in interest and importance all other known Tertiary deposits put together; and yet, with the exception of the case of the American tertiaries, these investigations have extended over very limited areas, and at Pikermi were confined to an extremely small space.

Such appear to me to be the chief events in the history of the progress of knowledge, during the last twenty years, which account for the changed feeling with which the doctrine of evolution is at present regarded by those who have followed the advance of biological science in respect of those problems which bear indirectly upon that doctrine.

But all this remains mere secondary evidence. It may remove dissent, but it does not compel assent. Primary and direct evidence in favor of evolution can be furnished only by paleontology. The geological record, so soon as it approaches completeness, must, when properly questioned, yield either an affirmative or a negative answer; if evolution has taken place, there will its mark be left; if it has not taken place, there will lie its refutation.

What was the state of matters in 1859? Let us hear Mr. Darwin, who may be trusted always to state the case against himself as strongly as possible.

"On this doctrine of the extermination of an infinitude of connecting links between the living and extinct inhabitants of the

world, and at each successive period between the extinct and still older species, why is not every geological formation charged with such links? Why does not every collection of fossil remains afford plain evidence of the gradation and mutation of the forms of life? We meet with no such evidence, and this is the most obvious and plausible of the many objections which may be urged against my theory."[5]

Nothing could have been more useful to the opposition than this characteristically candid avowal, twisted as it immediately was into an admission that the writer's views were contradicted by the facts of paleontology. But, in fact, Mr. Darwin made no such admission. What he says in effect is, not that paleontological evidence is against him, but that it is not distinctly in his favor; and, without attempting to attenuate the fact, he accounts for it by the scantiness and the imperfection of that evidence.

What is the state of the case now, when, as we have seen, the amount of our knowledge respecting the mammalia of the Tertiary epoch is increased fifty-fold, and in some directions even approaches completeness?

Simply this, that, if the doctrine of evolution had not existed, paleontologists must have invented it, so irresistibly is it forced upon the mind by the study of the remains of the Tertiary mammalia which have been brought to light since 1859.

Among the fossils of Pikermi, Gaudry found the successive stages by which the ancient civets passed into the more modern hyenas; through the Tertiary deposits of Western America, Marsh tracked the successive forms by which the ancient stock of the horse has passed into its present form; and innumerable less complete indications of the mode of evolution of other groups of the higher mammalia have been obtained.

In the remarkable memoir on the phosphorites of Quercy, to which I have referred, M. Filhol describes no fewer than seventeen varieties of the genus *Cynodictis* which fill up all the interval between the viverine animals and the bear-like dog *Amphicyon;* nor do I know any solid ground of objection to the supposition that in this *Cynodictis-Amphicyon* group we have the stock whence all the Viveridæ, Felidæ, Hyænidæ, Canidæ, and perhaps the Procyonidæ and Ursidæ, of the present fauna have been evolved. On the contrary, there is a great deal to be said in its favor.

In the course of summing up his results, M. Filhol observes:

"During the epoch of the phosphorites, great changes took place in animal forms, and almost the same types as those which now exist became defined from one another.

[5] "Origin of Species," first edition, p. 463.

"Under the influence of natural conditions of which we have no exact knowledge, though traces of them are discoverable, species have been modified in a thousand ways: races have arisen which, becoming fixed, have thus produced a corresponding number of secondary species."

In 1859, language of which this is an unintentional paraphrase, occurring in the "Origin of Species," was scouted as wild speculation; at present, it is a sober statement of the conclusions to which an acute and critically-minded investigator is led by large and patient study of the facts of paleontology. I venture to repeat what I have said before, that, so far as the animal world is concerned, evolution is no longer a speculation, but a statement of historical fact. It takes its place alongside of those accepted truths which must be taken into account by philosophers of all schools.

Thus when, on the first day of October next, the "Origin of Species" comes of age, the promise of its youth will be amply fulfilled; and we shall be prepared to congratulate the venerated author of the book, not only that the greatness of his achievement and its enduring influence upon the progress of knowledge have won him a place beside our Harvey; but, still more, that, like Harvey, he has lived long enough to outlast detraction and opposition, and to see the stone that the builders rejected become the headstone of the corner.

LIFE, HEREDITY AND EVOLUTION

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I. Concepts, Old and New

All our concepts or "explanations" of life have a twofold aspect and origin. On the one hand you and I, as distinct individuals, firmly believe in our own sovereignty or in some inborn power of initiative and some personal responsibility for our own actions. This internal, self-determining agency is sometimes called "heredity," sometimes the "soul."

On the other hand, all of us are compelled to recognize our subjection as well as our indebtedness to the world about us. In modern times we are apt to attribute our success or failure in life to what we vaguely call luck or circumstances or environments. In earlier days we were more likely to attribute our fate to the intervention of some friendly angel or to the machinations of some malicious devil, and so we made some effort, some surrender or some personal sacrifice in order to fit our ways to the ways of these mysterious deities. In social affairs, the "college," the "country," "education" or the "government," are popular names for modern deities in the "over there" beyond our reach or ken. To them we now offer up our sacrifices and look for succor, and on them we now lay the responsibility for our misfortunes. But now, as of old, all those causes too illusive to be caught and baptized with a distinctive name we summarily attribute to God, or nature, or predestination, or to some other indefinable but all-inclusive agency.

All these blanketing words are but the refuge and the ornaments of our ignorance. We use them either to cover up our mental nakedness or to escape from the necessity of making embarrassing distinctions. They "explain" everything, or nothing, depending on our definitions and our desire for particulars.

Thus the chief difference between old and new concepts of life is, and always will be, a difference in the sharpness of our mental delineations and the relative emphasis we place on particulars. And that depends on the extent and truthfulness of our knowledge and our reaction to the impact of its logic.

II. The Chromosome Theory of Heredity

In modern biology, the central concept of life is based on the make-up of the cell and its reactions to its environments. Our

body, like that of all the higher plants and animals, is virtually an empire of cells, wherein each cell is a sovereign state and the nucleus with its formalized chromosomes is its capital. These rod-like chromosomes and their invisible "factorial genes," as fickle and yet as unchangeable as human nature is supposed to be, are the central actors in the great drama of life, heredity and evolution. They are to the biologist what human beings are to the statesman and politician, what atoms and molecules are to the chemist and what protons and electrons are to the physicist and the electrical engineer.

But all these "units" of life, matter and energy are but convenient names for smaller working agencies acting under the compulsion of larger or more universal agencies. They are knowable only so far as we can measure their work or the fruits of their work and observe the ways in which they lawfully perform their creative services.

Our chief business and pleasure in life is to find out where and how that work is done that we may better appreciate its significance and play our part in life more intelligently and happily.

The chromosome theory, sometimes called the theory of *genes*, like every great theory, grew up in a narrow manger of obscurity from little incoherent facts that at first had no significance. But the more these "little facts" were combined with other facts in logical continuity and harmony, the more they glowed, like truth, with fruitful and amazing implications. And so, like the atomic theory and the theory of gravitation, growing by the assimilation of countless other facts, it radiated outward into larger fields and now casts its reflections on every phase of nature-action.

Thus the chromosome theory is not merely a theory of heredity. It has grown into a great coherent theory of life and evolution which includes parts of many other theories, such as those of Darwin, Lamarck, Weismann and Mendel, and which is deeply rooted in all the other sciences. Its central actors are the minute rod-like chromosomes and their factorial genes which are enthroned in the very centers of cell life. For a long time they have been regarded as the chief regulators or determinators of all cellular activities. In more recent times, this assumption has been surprisingly confirmed and broadened by the results of experimental breeding.

It now appears that every plant or animal may be regarded as a combination of various "characters," such as color, size, structural details and abilities. Such characters are called "unit characters" because they are often inherited as a unit or as a group of such units. The peculiar ways these characters are transmitted from parent to offspring clearly indicate that the factors or genes which

produced them are tied up in some structural container or carrier, such as a chromosome. Moreover, a statistical study of heredity shows that the "unit characters" of the parents are transmitted to their offspring in definite numerical ratios (Mendelian Law) comparable with the distribution and numerical combination of chromosomes that takes place in the germ cells during the initial stages of sexual reproduction.

Thus in death and sexual reproduction all the great problems of the biologist come to a focus. For living systems renew their life by dying. They grow again by returning in part to the one system that includes them all and which never dies. Special provision is made for this inevitable emergency. That is, some of the cells of the embryo are at once set apart, with little or no change in their initial structure and power of growth, as the germ cells of the new body. When that body has served its purpose and death draws near, all its marvelous machinery operates to set the germ cells free and to provide for them the ways and means for a new and larger life.

The contrasts of sex are but the contrasts in two sets of germinal, bodily and mental equipments, whose common function is to combine their resources and so create a larger and a more varied life. The perpetuation of life and progress depends on the fitness of the whole dual machinery of sex to bring about that result; that is, to bring two different kinds of germ cells into cooperative action, and then to nourish, shelter and guide the new life during its earlier stages of development.

In the preliminary preparations for their union (*maturation processes*) the chromosomes of each germ cell stretch out to great lengths and unite in pairs (synapsis). During this brief period they apparently exchange genes, like two players drawing one or more cards from each other's hands. Then two divisions take place (reducing divisions) the end result being that each mature germ cell or gamete receives about one half the initial number of chromosomes. Any one of the male gametes may then unite with or fertilize a female gamete of the same species and so initiate a new individual.

Thus in the game of life, the maturation processes virtually shuffle the hereditary pack and deal out half a "hand" to each gamete. A full hand is obtained by drawing a partner from the "board" or by combining with some other gamete of the opposite sex. And one of the "hands" always contains a bonus or a "jack pot" of golden yolk that was contributed as an "ante" by one of the players.

Hence offspring resemble their parents because they play the game of life with the same kind of cards, but not however with the same hands. The minor differences in offspring, or the variations from the standard type that always go with these basic resemblances, are due to variations in the distribution of the genes during maturation, fertilization and cleavage.

Thus sufficient stability and variety is produced to insure continuity and progress. For the offspring will in the main resemble those progenitors which have most successfully lived in the prevailing conditions of the past, but will be sufficiently different to insure that some of them shall successfully live in any conditions likely to arise in the future.

The chief purpose of sex and sexual reproduction, therefore, is to bring about this happy combination of stability and variety. For hereditary stability preserves the best of the past, while hereditary variation provides the necessary means for improvement.

Changes in the environments, such as climate, foods, associates, habits, etc., are always accompanied by corresponding changes in the structure and function of the cells that make up the body. But such changes ordinarily have no appreciable influence on the more stable genes and their combinations. Hence these so-called "acquired characters" will not be inherited. That is, they will not reappear in the next generation unless the environmental conditions are much the same as before, or unless the genes themselves have been modified.

Thus plants and animals, males and females, parents and offspring, are clock-like reciprocating mechanisms bound together in one "big union" wherein the gain or loss of one checks or accelerates, for better or worse, all the others. These clock-like mechanisms run with marvellous regularity and precision, partly because of their own activities and partly because they are wound up and regulated by such universal and steadfast agencies as atomic action, light, gravity and electricity.

This rhythmic alternation of bodily death and bodily regeneration has been going on without interruption for untold millions of years. It has produced the life we see to-day and in which we now participate. The heart of that creative process is hidden in the tiny chromosomes of the germ cells, but it takes the whole universe to make it beat and to guide its beating. That, very briefly, is the essence of the modern theory of heredity.

III. Methods, Principles, Virtues

The chromosome theory is now the backbone concept of the biologists. Around this central framework of interlocking facts and

theories circulate all their discussions and about it they are now assembling the more plastic phenomena of life in logical continuity and harmony.

But there are always a few adventurers who immediately ask "How far and where will this or that theory take us?" "What are its limitations?" And they at once "go the limit" in a quick mental test of its larger values. In fact both the peep-hole plodders and the wild-eyed adventurers are always testing the validity of ideas in that way, their "limit" depending on their range of vision and their faith in the "facts" with which their feet are shod.

On some minds the first effect of the modern concept of heredity and evolution has been completely to destroy the old values of life, leaving nothing but bewilderment and despair or the mental vacuum of agnosticism. In others, it has created a blissful faith in democracy and eugenics.

But all of us feel the need of faith in something, and to preserve that faith against assault we must have hard substantial facts to stand on and something tangible with which to test and strengthen the teeth of our beliefs. The cloud-capped altitudes of mystic high-brows are not the citadels of either faith or works. It is only the diggers and hewers of knowledge that can reveal to us the great facts in life and lead us out of the wilderness of little things in which we are entangled.

Let us follow up the trail of the biologists to their logical conclusions and see for ourselves where they go and what they show us. It may take us a long way from home and we shall have to travel in many excentric circles, large and small. For dynamic logic, like all natural phenomena, is cyclic. But any one who wants to go with me on this adventure may do so. We shall find it easy going if we leave all our superfluous mental baggage behind us and go in our naked commonsense.

Merely to expatiate on the wonders of nature and the uncertainties of life to a lost and starving wanderer is a mournful mockery. Any guide or captain worthy of the name should know his objective and how to get there. His knowledge should be positive as well as negative. Within his own province, he should surely know the right way from the wrong way, and he should exercise the full measure of moral and ethical guidance that belongs to his function. It is for him to dictate what must be done and what must not be done, in order to attain the desired goal.

The central concept of biology has been arbitrarily limited for convenience in presentation and in order temporarily to focus our attention on the more sharply defined body of biologic facts. But

in reality it has no limitations and it by no means contains the whole story of life.

There are other factors, other creative principles or virtues which can not be expressed in such definite structural and functional terms. Nevertheless they must be clearly recognized before we can grasp the larger and truer meaning of life and feel the impact of its logic.

These factors have been given many technical names which usually conceal their real meaning. But we shall boldly translate the dialects of science and philosophy into the more familiar terminology of everyday life. We need not be afraid of unduly humanizing what is not human. Fortunately, little enough of us is human. The obvious fact that inanimate and unintelligent things do act in accordance with these principles in no wise invalidates the principles themselves nor diminishes their significance. Indeed it should make them all the more significant to those who call themselves intelligent.

The chief difference between say an atom, a worm and a human being is that man has become more or less conscious of these creative principles or virtues and is "willing" to make some sacrifice of his own resources, bodily or otherwise, in order rightly to use them. Inanimate and unintelligent things apparently are not conscious of them and do not use them "willingly."

Discipline

All environments, great or small, have a dual influence on life that is disciplinary in methods and results. For they compel the living clocks and all their parts to run in certain ways and prevent them from running in certain other ways. Indeed every single thing in nature, great or small, living or dead, is subject to a directive discipline that may be expressed in the familiar terms: Thou shalt. Thou shalt not. Thou mayst. That is why there is law and order and mechanism in life and nature. That is why some things are possible and others impossible.

Work, Mutual Service, Cooperation, Anabolism

No clock, living or otherwise, can be made without labor. Neither can it "run" when it is made without the expenditure of some kind of work or service. Some "inside work" must be done to keep the parts together and to do the running. And some "outside work" must be done to bring the parts together in the first place and to provide them with opportunities to work and with the necessary power to do it.

Such a dual system of "inner" and "outer" service, supply and demand, is essential to the construction and existence of anything. For no one thing, proton or electron, plant or animal, sun or satellite, can do any work all by itself. It must have something to pull or push against, and it must be pushed or pulled by something else. So all nature's work is cooperative work, and before any work whatever can be done, the workers must be mutually serviceable for the doing of that work. Therefore whatever things exist is, in itself, conclusive evidence that such services have been and still are performed. In chemical and protoplasmic domains, the biologist calls this upbuilding or constructive work anabolism.

Usage, Destruction, Sacrifice

But to do anything, something must be "used up" in doing it. That is, something must be diverted from its former state, remodeled, destroyed or sacrificed, before it can serve in whole or in part for the doing of something else. The biologist calls this preliminary breaking down and diversion of chemical power and materials for vital usage katabolism. All previously engaged materials and power must be liberated and redistributed in some such ways before they can be utilized in any other constructive process.

Life, Business, Exchange, Metabolism

This rhythmic down-breaking and upbuilding of bodily structures, together with the circulation of necessary working materials and power between producers and consumers, is called metabolism. To the biologist, it is the surest evidence of life, both in the simplest bits of protoplasm where all other evidence of life is lacking, and in the highest animals where all the bodily functions and organs so obviously collaborate in this vital business.

In the larger circles of human affairs, the whole complex of making, transporting, using and exchanging the commodities of life is called business and, to a "business man," it is the surest evidence of social life. He sees in all this producing and consuming, supplying and demanding, the ways and means by which the human participants "make a living" and, like the biologist, he measures that "business" by the ebb and flow of the accompanying activities and the rates of exchange.

In nature every "unit," large or small, living or dead, is a worker. It is both an actor and a reactor, a producer and a consumer, a center of supply and a center of demand. It is a part, but an inseparable part, as we all are, of that universal working we call nature-action. We act with and react to other workers. That is how and why we "feel" them; and by that compelling evidence we

become aware of their existence. And so in all the operations of nature that directly or indirectly make a sensory appeal to us, in all the phenomena of transformation, circulation and exchange, whether on the stupendous scale of the heavenly bodies or the infinitesimal scale of protons and electrons, we "feel" the evidence of these operations of nature and finally become conscious of that universal business whereby the ways and means of creation are prepared and duly delivered to all her workers.

Profits, Heritages, Benevolence

But in any growing business there must be something more than a flat exchange of values. There must be some gain or profit in the transactions by means of which the business can better carry on and enlarge its undertakings. But before there can be any betterment in service, better ways and means of working must be provided for the workers to work with. That is, something must be transmitted in the nature of a gift, heritage or endowment from the old to the new. Hence something essentially like what we call benevolence or altruism is an indispensable factor in every phase of creative progress. It is the way all profits must be utilized before continuous life and growth can be insured.

It is obvious that the whole purpose of the chromosome mechanism of inheritance is the transmission of the gains of life, in the compact form of germinal structures, to other individuals that are in a condition to make further or better use of them. In return, all the bodily powers of the inheritors are utilized in a lifelong effort to supply these germinal trust funds with sustaining foods and in striving to protect and guide them in the further performance of their functions. Because that work has been well done ever since the beginning of life is one of the reasons why the germ cells are immortal and why these trust funds have steadily accumulated in creative values.

But this reciprocating system of parents and offspring can not work in a vacuum. It must have sustaining and directive soils to live and grow in, such as cosmic, terrestrial, social and mental environments and something to provide beforehand these environmental ways and means of living. All that has been duly provided. Hence all these external conditions that life is heir to are but larger kinds of heritages which, like all heritages, have been created by the labor and sacrifice of the past and made available for present and future uses. They are the larger factors that drive life onwards and upwards and which broadly direct and regulate every phase of germinal and bodily life, human or otherwise.

Variation Freedom

But although nature-action is always lawful and orderly, it is never rigidly mechanical or unyielding, otherwise improvements would be impossible. Every part, organ or individual and all their environments change in some respects from time to time. Hence there is always a certain degree of flexibility, a narrow zone of freedom within which departures from the usual modes of procedure are possible without disaster. When those departures occur, say in an atom, the sun, a plant or animal, or in any of their parts or organs, we speak of it as some intrinsic variation of the thing itself, either in its structure or behavior, or both.

In respect to human affairs, this zone of permissible variation is called freedom. But that freedom is always checked or limited by those environmental conditions on which the very existence of human life depends. To go beyond those shadowy limits into abnormal bodily structure, thought or behavior cuts down the opportunities of life in some respects and always destroys those who go too far.

But within those prescribed limitations there is full freedom of action, with countless inviting opportunities to rest, play, adventure and explore. That freedom to seek and try new ways of doing things, that open road to trial and error, is essential to human progress, to happiness and the hope of still better things. It is a universal heritage, the most precious of all heritages, to inanimate as well as animate things.

The Selective Law

Thus for the very reason that there is both rigidity and flexibility in the order of the universe, there is freedom and compulsion, restraint and opportunity, reward and punishment. That is, there is a dual selective process in perpetual operation which on the one hand favors with further opportunities whatever things are mutually adaptable and mutually serviceable, and which handicaps or destroys those that are not. The result is an increasing degree of rightness in the universe for the accomplishment of whatever end or goal or purpose there may be to accomplish.

This may be expressed in more explicit terms as follows. If any part or organ or thing is better fitted to give help and receive help, it will last longer and create bigger or better things in accordance with the degree of help or service performed. The less helpful things are soonest eliminated, corrected or destroyed. This two-edged justice, which does not permit the over-monstrous to endure, and which favors the more righteous with further life and opportunity, is called the selective law. That is why nature is so fittingly

or adaptively organized. That is why there is art and beauty in nature and ever-widening cycles of creative accomplishment.

Rightness

Because of this inherent flexibility in nature-action, perfection in structure or behavior is unattainable. The approach to perfection only makes perfection recede in the new order thereby created.

The biologist estimates progress in terms of orienting tropisms, or in terms of adaptive adjustments in bodily structure and behavior to the great environmental agencies (such as light, gravity, soils, water and air) in which they live and have their being, and to other living things with which they are associated. That is the only way they can "make progress" or accumulate vital profits.

The measure of that profit or progress is not merely the volume and elaboration of life individually or socially, but the rightness of these functional adjustments in themselves as a means of creation or present existence, and also their rightness as a means for still higher achievements in the future.

In man, there has been added to these more basic tropisms what may be called mental tropisms or the adaptive adjustments of bits of knowledge and ideas to one another (subjectively) and to what actually goes on in the world about him (objectively). These mental corrections of a dawning or growing intelligence provided him with new mental light or new vistas of the creative process, and with them came new power or new sets of compelling motives which sooner or later were expressed in his behavior.

Thus the value of knowledge or wisdom or intelligence depends on its rightness or trueness and on the creative profits that spring from its usage. For instance, when we observe human beings at work or play, we are apt to think there is something right or wrong in it, according to our ideas of the fitness or unfitness of things in general or what we think ought or ought not to be done. And when we look beyond human affairs and observe what is going on in the larger world of nature all about us, we see that things are often done in a shockingly different way from what we expected or believed was right. That makes us want to reform the world so that it will better fit our own ideas and our own convenience.

But when we look a little longer and more thoughtfully, we discover that nature, in her big, slow and methodical ways, is always doing something and is always getting better or larger creative results. And so we can not avoid the conclusion that after all, her ways must be the real ways, the true ways, the right ways, that we are all seeking to discover and to utilize. That makes us want to know still more about them, so that we can better obey them or imi-

tate them or adjust our ways to them and thereby live more profitably.

These mental tropisms of man, as in the architectural (triaxial system) and behavioristic tropisms in plants and animals, are internal adaptive responses to compelling agencies that are external and superior to life. In that superior power is the source of man's truth-seeking spirit and his spirit of service. It is the source of his faith and his hope of better things, whether it is the faith of the scientist in the immutability and justice of natural laws, the faith of the statesman in social institutions, or the faith of a child in its parents or its God.

Thus man's insatiable hunger for knowledge is not a sterile appetite to be fed on facts and satisfied by fruitless thinking. Nor are his artistic longings mere playthings to be spent on fantastic imaginings. These compelling desires are fruitful creative agencies whose purpose is to make men *do* something that sooner or later can be cashed in serviceable realities. For the fruit of thought is service. And service generates purpose. It gives direction and effectiveness to thought and dignity to work, and *that* makes life worth living.

Progress Purpose

There are as many different kinds of progress as there are things done and undone. And since the doing of anything always upsets the previous state of supply and demand between the giver and receiver, producer and consumer, "disturbance of interests" and conflicts of opinion in regard to them inevitably arise, depending on what is done, how it is done and what things are used in doing it. For example, in the making of a pile of bricks or in the unmaking of that pile by moving them to some other place, our estimates of purpose and progress largely depend on whether our own bricks are rightfully moved to the right places in our own buildings, or by a child to the middle of the parlor floor. And in the making and unmaking of a molecule, a cell, a city or a star, or in the moving of a professor from one institution to another, or a flea from one dog to another, our estimates of purpose and progress largely depend on our vested interests in what is used and whose dog or what institution is the beneficiary.

The rhythmic sequence of factors in the accomplishment of anything may be concisely stated as follows: (1) The right (2) using (3) of something (4) for making (5) something else—(1) which (2) is then fit or right (3) for use (4) in making (5) some other thing, etc. Thus the chief factors in any one "element of progress" are rightness, usage and the making or doing of something that is useful. When many such elements follow one another consecutively or methodically that method is evidence of some purpose in the doing of that which is accomplished by it.

In nature there is an infinite number and variety of makings and unmakings with the conveyance of the right materials and power from one time and place to another for their accomplishment. All of them are progressive and purposeful in character and all of them are methodically used in the making of what we call evolutionary progress. Evolution, therefore, is conclusive evidence that there is one grand strategic purpose in all these elementary purposes.

Unchanging Principles and Changing Values

Thus something essentially like what we call discipline, freedom, service, self-sacrifice, benevolence and purpose are indispensable factors in every phase of life, heredity and evolution. Indeed such moral and ethical principles, methods or virtues, it matters little what we call them, are essential prerequisites to the existence and accomplishment of anything. They are immortal or unchangeable, and so axiomatic, so obviously productive of "results," that the most primitive people have not failed to observe them and, more or less consciously, have crudely tried to imitate them in order to obtain the results they most desired. Hence they constitute the basic principles of the oldest systems of social government, ethics and morality, science and religion, of mankind. Then, ignoring his racial achievements and his methods of achievement, man vainly assumes that these virtues are purely human inventions and that he is the only one that uses them!

But when we try to "explain" anything or to discover the particular cause or causes of any one event, we find ourselves utterly unable to do so. The causes of any one event are infinite in number and variety; some are immediate, others more remote and others have their source in the very beginning of all things. Since we can not know all the factors in any one event, however elementary it may be, we never can measure the value of that event, or any one of the factors that caused it, even if all our instruments and methods were perfect, which of course they never can be.

No wonder there is confusion and disagreement among men whenever any one, however learned he may be, tries to explain this or that event in terms of time, space, numbers or energy. They never can be explained in such terms because the creative value of the things themselves is changeable and because there is always an unknowable remainder that is bigger than all the knowable ones put together. Moreover, the one strategic purpose, end or goal that determines all values is a secret no man can know.

The best we can do is to make some tentative explanation, or form some temporary judgment based on the fulness and the radius of our sphere of knowledge. But in making and weighing those

judgments we always use these fundamental virtues as our standards of measurement because, consciously or unconsciously, we have learned that they are the invariable attributes of all causes. In other words, these virtues are in themselves conclusive evidence of that one cause of all things that we call God.

* * *

With the rapid growth of knowledge and the spirit of inquiry, especially during the last century or two, the logical necessity for some unity of method and purpose in natural laws became more and more apparent, not merely to coordinate and vitalize the vast accumulation of incoherent facts, but to reveal their deeper and more religious significance. Strangely enough, when that revelation came, it was celebrated more as a funeral than a birth, as the oncoming of a night of chaos, not as the dawning of a new day. And the spiritual light of evolution went out in mental rioting over trivialities and a bitter struggle for leadership and authority between the partisans of the old and new beliefs.

During that dismal period, whose clouds still hang over us, the old formulas lost their convincing logic, and with it their motive power. The new formulas had no moral or ethical compulsion, no objectives beyond thinly disguised selfish interests. And the new leaders had nothing better to offer than a futile struggle for existence between sheer physical forces and shallow wits.

But with no convincing and therefore compelling authority to guide it, nothing external to work with and for, there can be no rational motive in life. And a self-centered life is automatically suicidal. Thus science, religion, art and politics inevitably degenerated into empty absurdities without unity in language, thought, method or purpose. There was nothing on the horizon of hope to work for beyond the immediate pleasures and necessities of life, and even life itself seemed unnecessary. And then came the penalty!

Now, in calmer moments and with surer knowledge, the inevitable logic of events again directs our judgments. Our clarified vision reveals an unending vista of creative progress. Its records are written in every fiber of nature, root and branch, for all that care to read them, and the God-like methods by which it was accomplished are everywhere manifest.

The logical impact of that revelation is irresistible. Life again is beautiful and pregnant with hope. For nature, the bridegroom of life, has renewed its promise and reaffirmed its guardian purpose. We know the creative way, the way of the old familiar virtues, of discipline and freedom, of mutual service, sacrifice and benevolence, of truth, understanding and righteousness; and we know that in those ways we may live and grow as our heart desires.

EVIDENCES FOR EVOLUTION

SCIENCE SERVICE, WASHINGTON, D. C.

NEW TYPES OF LIFE

By Dr. C. B. DAVENPORT

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THE fundamentalist complains that his faith and that of his children is being shaken by the discoveries and conclusions of the biologist. This faith is based on the teaching, directly or indirectly, of the clergy whose statements the fundamentalist accepts as truth. The biologist has a faith also which is very precious to him and that faith is based on observation of nature and the experimental study of nature's phenomena, and for him the answers that nature gives to his questions are more significant than the assertions of the clergy.

Fundamentalists accept what they have been told about the accuracy of description of the origin of the universe given in the Scriptures. The biologist will accept the authority of no man, not even the man who presumes to state that the description of the origin of the world in the Bible is the "word of God." The biologist has his own idea of what is the word of God. He believes it to be the testimony of nature. This testimony has to be wrung, as it were, out of nature, but in this way evidence can be secured and has been secured that is incontrovertible.

Among the many lines of evidence, one of the most significant is that derived by the study of the origin of new forms under domestication. All kinds of organisms were not made at the beginning of the world. There are now thousands of forms of animals and plants that reproduce their kind which did not exist a century ago. Within the last ten years there have been produced scores of forms of the banana fly never before seen by the eye of man. Indeed, the very day on which the ancestors of some new types first appeared is known and many of these types have persisted to the present day.

We know indeed not a few forms which have appeared recently and which fulfil the essential conditions of species as the naturalist finds them in nature. These forms differ by two or more constant traits from other species. They are quite as infertile with other species as some wild species are with each other. The principal difference between them and wild species is that their beginnings have been seen and are known to be recent while that of wild species has

not been seen and so their origin is of unknown date. But it is known that thousands of wild species that we have on earth to-day did not exist in earlier geological ages, just as there are thousands of species that lived in past geological ages that are not living to-day.

The conception of a world that does not change is one that may have seemed possible to monks shut in their cells; but every one who has traveled and observed widely knows that the face of the earth is changing; and every one who has lived with and bred animals and plants knows that they too are changing.

VARIATIONS AND MUTATIONS

By Dr. VERNON KELLOGG

PERMANENT SECRETARY, NATIONAL RESEARCH COUNCIL

When any kind of animal or plant produces offspring these young resemble their parents—but never exactly. There are always differences; lesser or greater. These differences are called variations.

Most of these variations are mere fluctuations around a mean and are not necessarily repeated in the next generation. Some of them, which may be more marked, are undoubtedly due to varying environmental influences and also are not repeated in later generations unless these generations are reared under the same kind of environment.

But sometimes some of these variations reappear in the next and all the succeeding generations, even though the environment surrounding the development of these succeeding generations is not the same as that which surrounded the first generation in which the variations appeared. Such variations are inherited. They breed true.

Such heritable or fixed variations are called mutations, meaning that from one kind of plant or animal a new kind has been produced by a persisting change or sudden little jump. This is the production of a new kind of animal or plant. This is species-forming by mutation. It is the easiest kind of origin of species to observe. It has been observed by many naturalists. These naturalists have seen evolution actually happening.

A kind of little fly, called fruit-fly, which has been very carefully studied for several years by various naturalists, chief of whom is the American zoologist, Professor T. H. Morgan, of Columbia University, has given rise, under their eyes, to many mutations. These are new kinds of fruit flies. Most of them are not kinds better fitted for existence than the original kind of fly from which they

arose. But some are sufficiently fit to persist. They can hold their own in the struggle for existence. They are new additions to the kinds of fruit-flies. They are visible evidences of the present-day evolution of animal kinds.

Similarly, botanists have seen new kinds of plants arise by mutations. The most famous cases of this kind are the mutations of the evening primrose, first carefully observed and described by the great Dutch botanist De Vries, of the University of Amsterdam, and later observed and studied by German, English and American botanists. These new kinds of evening primroses, arising by fixed "jumps" or mutations from a species called Lamarck's evening primrose, are visible evidences of the present-day evolution of plant kinds.

THE EMOTIONS IN MAN AND ANIMALS

By Dr. WILLIAM E. RITTER

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Down to a few years ago nearly all the facts on which rested the hypothesis that man originated from lower forms of life by some marvelous process of natural transformation were drawn from studies on bodily structure. Fossil remains, physical organization of men and other creatures now living and developing embryos were the almost exclusive sources of such facts.

But now that researches into the activities and mental life of all sorts of men, in comparison with all sorts of inferior beings, has been and is being pursued on a vast scale and with great accuracy facts from this other source apparently having the same meaning are coming to light in astonishing numbers. Charles Darwin foreshadowed the new era of investigation by his book "The Expression of the Emotions in Man and Animals." But the most positively scientific gate-opening into this great realm was made nearly simultaneously by the American psychologist, William James, and the Danish physiologist, Carl Lange. The combined results of these initial labors was what is known as the James-Lange theory of the emotions.

The main facts invoked by this theory are too obvious to escape any one: All emotional stages as of joy, grief, fear, anger, jealousy, love, are associated with more or less characteristic bodily manifestation, these often seeming to involve the entire physical framework. The theory says the bodily states thus manifested actually constitute the emotions. It is not, as the older theories had it, that the body is played upon, as it were, by some independent entity,

as a spirit, something as a piano is played upon by a pianist, but that the living organism's mode of responding to certain influences from the external world are the emotions.

With some modification later research has strengthened and extended this theory. All our sentiments, emotions, passions, the noblest and the basest alike, are the working together in response to stimulation of sense organs, nerves, muscles, blood vessels, viscera, glands. Finally, only yesterday and to-day come the discoveries of internal secretions and vitamins which are essentially special agencies for exciting the various body parts to their appropriate actions. Consequently, so much to the front have the activities of animal organisms been brought by the new discoveries and theories that reflex actions, tropisms, instincts, appetites, emotions, passions, have become the central interests of the day not only in the science of mind but in art, in literature and in nearly all practical life.

And through these activities, subject as they surely are to the laws of physiology and heredity, man's identification with the whole of living nature is made direct and inevitable. There is not an item in the list of structures and activities mentioned that is not common to men and some, if not the whole, of the animal world.

If all this does not mean filiation by descent with animate nature generally, what does it mean? We have reached a point in the study of man where it becomes clear that whatever theory of his origin shall finally prevail must be accordant with the major facts of his daily life. And any one who would contend that these facts do not necessitate belief in some form of evolution or natural transformation is compelled by the fact that he himself possesses the power of reason to produce a rational theory of his origin that accords better with the facts of his own nature and the nature of all living beings than does any transformational theory.

PROOF OF MAN'S CULTURAL EVOLUTION

By Dr. GEORGE GRANT MacCURDY

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THE evolution of human culture is well exemplified by a study of the artifacts of the Old Stone Age in Europe. This age covered a period of several hundred thousand years. It is commonly divided into two periods—the Eolithic and the Paleolithic; the latter is subdivided into Lower, Middle and Upper Paleolithic. Cultural evolution has its parallel in organic evolution and, like the latter, its pathway is strewn with extinct forms. Of the two, cultural evo-

lution is subject to more rapid changes, its chief basis being human inventiveness. One invention leads to others by a system of budding and branching; so that a single invention may give rise to a whole cluster of related activities forming what might be called a culture-complex unit. The oldest clusters of human activities of which we have definite knowledge are the lithic and fire complexes; the lithic complex was superseded in part and supplemented by the use of such organic materials as bone, ivory and reindeer horn, which characterized the game-animal complex.

In a comparative study of the industrial remains of these various periods, there are certain broad distinctions to be drawn. Eolithic industry consisted largely of improvisations—of primary tools or implements such as the hammer-stone and the flint chip with utilizable edge or point. Secondary tools were few and simple, consisting largely of artificial chips; during the Lower Paleolithic period, the number of secondary tools was increased by the addition of the cleaver, a pointed implement chipped on both faces. A primary tool is one ready to hand—furnished by nature; a secondary tool is one which requires the use of a tool in its manufacture; tertiary tools are those which in their shaping require the use of primary and secondary tools and whose ultimate purpose is not the shaping of implements.

The Neandertalians of the Middle Paleolithic Period made no great advances over their predecessors. They possessed an improved technique, which is seen in the character of their nuclei and well-formed scrapers and points with carefully retouched margins; but so far as can be ascertained they did not go beyond the making of secondary tools—that is to say, their secondary tools served directly an ultimate purpose, were not used for the manufacture of tertiary tools. The technical processes from Pliocene times to the close of the Middle Paleolithic Period (well along toward the close of the Pleistocene) remained relatively simple.

It was reserved for the Upper Paleolithic Cro-Magnon races to inaugurate a new era. This was made possible through improvement in the preparation of nuclei from which long slender blades could be struck. The next step was important additions to their stock of secondary tools (various forms of the graver, microliths, small knives and awls) which enabled them to make extended use of bone, ivory and reindeer horn, leading to two capital results—the invention of a set of tertiary tools and the dawn of the fine arts.

Upper Paleolithic or Cro-Magnon culture was very early transformed through the addition of the secondary shaping tools produced from bladelike flint flakes, without which it would not have been possible to make an array of tertiary tools such as the bone needle, the javelin point of bone, ivory or reindeer horn, the javelin

shaft, the dart or javelin thrower and the harpoon of reindeer horn; nor would the Cro-Magnons have been able to embellish their dart throwers and satisfy a rapidly developing artistic sense by producing various objects of art and of personal adornment.

CONTEMPORARY EVOLUTION OF SOUTH SEA ISLAND SNAILS

By Dr. HENRY E. CRAMPTON

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To the majority of people evolution means a long line of successive generations, and the production of a new kind of living thing differing from its earlier ancestors to such an extent that it can justly be called a new species. This is evolution, it is true, but the special student knows that the larger differences which come about in long time are the accumulated smaller variations such as all creatures display when they are compared with their immediate parents. No one has yet found a single animal or plant that is exactly like either of its progenitors or like another of its own family. Hence every one knows that "individual differences" come about naturally. When such differences are summed up in time to be more obvious contrasts, we speak of "varieties," or "sub-species"; and when two kinds of descendants from common ancestry come to be even more separate they are called species.

During nineteen years, the present writer has been investigating the processes of change displayed by some of the land-snails that live in the forests and jungles of many islands of the South Seas. At first sight, the animals do not seem interesting, but nevertheless their study has revealed abundant evidences that new "kinds" have actually come into existence within that short period of time. Some of these "kinds" are only slightly different from their parent stock, but others are more distinct, and, as real varieties, they are well on their way to the status of new species.

The evidences in question have been secured through a fortunate combination of circumstances. An American naturalist named Garrett worked among the islands of the great Pacific Ocean during many decades of the nineteenth century, and he left full descriptions of the species of snails belonging to a genus called Partula, as they were distributed in his time. He showed how each group of islands possesses its own species not found elsewhere, and how each island of a single group is the home of unique kinds which are closely related to the species of nearby places but which have come to be distinct in correlation with the separation of the islands where

they occur. Furthermore, the different valleys of an individual island, like Tahiti, bear distinct varieties of one and the same species, which are even more nearly related to one another, as their differences are relatively slight in degree.

My own work consisted in going over much of the ground covered by Garrett, collecting all the species and varieties in the various valleys and islands, and comparing them as they now exist with what Garrett observed and described. Many a colony proves to be a much changed assemblage when contrasted with what it was a few decades ago.

Perhaps the most striking evidences were found in Moorea, an island near Tahiti in the Southern Seas. Eighteen years ago, new "kinds" were found which were apparently not known to Garrett, and which could not have been present in his time in the valleys where they first came to light. It is still more important that the writer has found during the last three years new kinds of very distinct nature which had not been present in the same areas sixteen years previously. Many of these are what the biologist calls "mutations," or offspring that differ from their immediate forebears in very obvious respects and degrees. For example, a few rare specimens possess shells that twist in a spiral that is the exact opposite of what the parent had. Others are "dwarfs," while still others display patterns of color that are unique.

Thus we have in nature the elementary episodes of real bodily change that need only to be added up during successive generations to result in the production of varieties and even species of new character. It does not require very much in the way of reasoning to recognize that such elementary episodes are just as truly evolution as the longer process of organic change which is accomplished merely by the summing up or accumulation of the small diversities that come about with every new generation.

MAN'S EMBRYONIC TAIL

By Dr. ADOLPH H. SCHULTZ

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How can a self-respecting scientist claim that his and everybody else's ancestors once possessed tails like those of monkeys? For no less a reason than that every man at an early stage in his own life-time is ornamented with such an appendage, which, to be true, serves no other purpose than that perhaps of making him feel justly proud of the fact that this organ long ago ceased to be a permanent part of his outer body.

The embryologist has irrefutable and abundant proof to demonstrate that man, long before birth and when measuring but a third of an inch, bears a true external tail one sixth the length of his body. This tail projects for a considerable distance beyond the place where the legs branch from the trunk. It contains anywhere from 7 to 9 vertebral rudiments, bringing the total number of segments in the spinal column to as many as 38. This tail soon becomes completely overgrown by neighboring parts and disappears from the surface. Some of the vertebral rudiments become resorbed so that in adult man there are only 4 or 5 of them left—small vestigial bones of the so-called coccyx at the lower end of the spine which in adult man consists of only 33 or 34 vertebrae. Even the last of these lies in full-grown man, when sitting on a chair, very considerably above the seat. This goes to show that the embryonic tail of man, particularly the bony elements in it, shifts in an upward direction in the course of growth. The spinal cord projects at first beyond the thirty-eighth vertebra, that is to say to the outermost tip of the tail; with the advance in age this vital part of his nervous system also migrates upward, and even more so than does the spinal column, since in the adult the cord reaches only as far as the twenty-first vertebra.

Embryology furnishes still further justification for comparing the vertebral rudiments in the tail of unborn man with the tail vertebrae in monkeys. In many of the latter are found on the lower side of the first few caudal vertebrae typical so-called chevron bones, which protect the blood vessels supplying the well-functioning tail. In an exactly corresponding place in the human embryo occur rudimentary structures which can unmistakably be identified as nothing else but these chevron bones.

The undoubted tail vertebrae, amounting in total length to about 16 per cent. of the sitting height in the embryo, have shrunk in adult man to less than 4 per cent. of the latter measurement. Even in adult life these last segments of the spine are readily diagnosed by the muscles, which are attached to them, as true tail vertebrae. In some individuals a greater variety of these muscles is found than in others; they are always of a rudimentary character, but they invariably correspond to muscles found in the tails of monkeys. Whereas in man they are no longer capable of wagging the tail, which has become internal, their purposeless existence can alone be explained as last vestiges of formerly well-functioning muscles.

The regular, normal occurrence of a proportionately large outer tail at an early and temporary stage in the development of man, together with the unequivocal remnants of true tail vertebrae and muscles, in the full-grown person, forms overwhelming evidence for

the only logical assumption that man, as well as monkey, descended from ancestors with well-developed tails. Only from such progenitors—no matter how remote—can man have acquired these absolutely useless but significant structures, and, indeed, this reminds one of the passage in the Bible: "The sins of the fathers shall be visited upon the children!"

In some apes, notably the orang-outang, the evolutionary reduction of the tail has gone further than in man, since in the former only three, sometimes two, tail vertebrae have remained and the adjoining muscles are still more rudimentary than in man's own anatomy. Moreover, a human being is born occasionally with an outer tail. Such a case, for instance, occurred some few years ago in Baltimore, and a reputable scientific journal gives an account of a twelve-year-old boy who had an outer tail of the record length of nine inches. These so-called soft tails contain no vertebrae, but blood vessels, muscles and nerves, and are of the same consistency as the short tail of the Barbary ape.

The embryologist in searching for truth in his field can not escape noting the striking resemblances between man, ape and monkey in early development which can be understood only by assuming one common origin for all, from which they inherited the tendency for the same growth processes. These processes have become modified in certain forms through a variety of later specializations. A long chain of proof has been produced by science for the further conclusion that the human body in a number of points is less removed from ancestral conditions, and hence remained in some parts more original and primitive than have some of man's simian cousins.

EVOLUTION AS AN ALLY OF RELIGION

By Dr. WILLIAM PATTEN

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It is obvious that the outstanding teachings of evolution are the same as the familiar teachings of religion. For the universal reign of law and order, which it has been the special privilege of science to reveal, is nothing more or less than the revelation that nature is a unified cooperative system, and that those better results, called evolution, are only achieved through better mutual service by all its constituent parts, and by their better submission, or adaptation to one another's requirements. That is the essence of the moral and ethical teachings of Christianity, as it is the essence of the moral and ethical teachings of evolution.

And the law of "natural selection," which is the essence of the much maligned "Darwinism," is in reality the expression of a discriminating, selective action in nature, in effect identical with the discriminating disciplinary laws of religion.

This disciplinary natural law merely means that whatever is fitting, or right, or true, whether it is physical, or organic, or vital, or spiritual in its nature, shall prevail, and shall yield its appropriate fruits. If it is not fitting, or if it is not right, or not true, it shall be fruitless, and shall not prevail.

In other words, truth has a saving power and a creative compulsion of its own. We call it the compulsion of intelligence. That is *why* man is compelled to seek the truth and to use it for his own salvation and betterment. And the *doing of that* is what we call science. But if we do not use the truth when it is discovered, if the truth when it is discovered does not make us work and direct our work, if it is not reverified in terms of human conduct, science will be sterile; it will neither bear its appropriate fruit nor have the vitality of reality.

Thus this compelling pragmatic law, which Darwin so clearly saw in operation in plant and animal life, and which he called "natural selection," is the same law that is so clearly expressed in Biblical teachings, as for example:

> And even now the axe is laid unto the roots of the trees: therefore every tree which bringeth not forth good fruit is hewn down and cast into the fire. But the root of the righteous shall not be moved.

And so, if we attempt to summarize the creative methods of evolution and to estimate their directive influence on ourselves, physically and mentally, it is not surprising that the narrower terminology of science inevitably changes into the broader moral and ethical terminology of idealism, or religion, or into that of any real creative process, such as art, business or politics.

This means that in the last analysis religion is merely a different name for science; the one being chiefly concerned with the immeasurable oneness, or godliness of nature-action, the other with its measurable manyness, or its distinguishable parts. But both seek to discover, to interpret and to utilize the same realities; and when that is rightly done they will be in ethical agreement; that is, they will dictate to mankind essentially the same conduct and justify essentially the same faith.

Thus science and religion offer the same incentives to action and have the same purposes to accomplish; and science expresses in her more comprehensive formulas precisely what all the great religions of the past and present have tried to express in their teachings, but without that sure and intimate knowledge of nature-action which

science gives us, and which is so essential to the truthfulness and sanity of any kind of religion.

I repeat, there is no difference between what is vital in science and what is vital in religion. In fact, underneath, science *is* religion, and religion *is* science. The differences which cause so much confusion are in their protective coverings of dogmas, ceremonials and procedures. They are differences between people; between those with more or less scientific qualities of mind and those who have little or no such qualities.

And so, it seems to me that the study of evolution, *as a whole*, more than anything else, will help to minimize the antagonism between religiously minded and scientifically minded people, and will help them to work more peacefully and happily together. For young and old, for high-brow and low-brow, the study of evolution makes life more significant and more beautiful. It justifies their faith and fortifies their ideals. It makes God a more imminent reality. It helps all of us to understand the purpose of life and how to accomplish it.

That is why I teach evolution.

BLOOD REACTIONS OF MAN AND ANIMALS

By Dr. MICHAEL F. GUYER

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SINCE Darwin's day important new evidence of evolution has been discovered, based on certain blood tests which give a scale of relationships among various groups of animals. Some years ago Reichert and Brown showed that in different kinds of structurally related animals the corresponding proteins and other vital substances of the different species exhibit chemically the same degree of relationship as that indicated by their position in the zoological scheme of classification. Thus, when the red coloring matter of the blood is reduced to crystalline form in blood from different kinds of backboned animals, although each species has its own individual type of crystal, the crystals of all species belonging to the same genus fall within the same crystallographic system, and generally within the same group in that system. Reichert, furthermore, has shown chemical relationships of the same general nature in the starches and tissues of parent plants to those of the hybrids between such plants. In other words, the more nearly related in classification different kinds of plants or animals are, the more nearly identical they are in their underlying chemical constitution. Such a condition is exactly what would be expected if the forms in question have evolved from a common ancestry.

But an even more convincing demonstration of evolutionary relationships is to be found in the reactions of the blood-serum of animals under certain conditions. When into the bloodstream of a given animal, for example, protein from an animal of different species or from a plant is injected, the animal so treated will have antagonistic or neutralizing substances of various kinds termed antibodies developed in its blood. Thus poisons called toxins, derived from bacteria, produce anti-toxins. Invading bacteria also lead to the production of sticky substances which clump bacteria of the kind used in their production if the two are brought together in the blood-serum of the animal into which the bacteria were originally introduced. Likewise a tissue or even the blood-serum of one kind of animal injected into the circulation of another animal of different species brings about the formation of a class of antibodies known as precipitins. These form a precipitate when the blood-serum of the treated animal and an extract of the special tissue used are brought together in a test tube. All such immunological reactions show considerable degree of specificity; the antibody will react fully only with the particular kind of protein used in its production.

In a remarkable series of studies in which he examined the blood from 900 different animals, Nuttall demonstrated some twenty years ago that by the precipitin test a scale of actual blood relationships among animals can be established. Recent refinements of the method together with the employment of other types of blood reaction all tend to confirm his conclusions. If, for example, a rabbit has been repeatedly injected with human blood, its blood-serum when mixed with slightly diluted human blood-serum in a test-tube will almost instantly yield a noticeable precipitate, although a control mixture of human blood-serum and the blood-serum of an untreated rabbit will remain clear. Closeness of relationship is determined by finding the dilution in which the serum tested will react. For instance, Nuttall found that when rabbit-serum which earlier had been treated with human blood-serum is mixed with moderately diluted blood-serum of man, apes and monkeys, respectively, it reacts to all, though in varying degree. When mixed with more highly diluted sera from such animals it forms a precipitate only with the serum of man and the manlike apes (chimpanzee, orang-outang, gorilla), the chimpanzee standing nearest to man.

Thus the chemical and other physiological processes of living organisms no less than their anatomical structures or geological history point to a relationship of various species which is intelligible only upon the influence that such species have sprung from a common ancestry.

THE RELATIONSHIP OF MAN AND ANIMALS

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WHILE much of the evidence on the evolution question is technical and complicated, there is one broad view of the matter that is plain and simple, and it is this broad, simple view that really makes evolution so appealing an idea to all students of plant and animal life.

As you drive along a country road, you come across a poultry farm where all the chickens are pure white. A little farther along, you see another with all red chickens. You ask how it happens that one farmer has all white chickens, and the other all red; and the answer is that one is incubating eggs from one breed of hens, and the other from another breed. The pure white hens have a common ancestry and are all blood relations. So of the reds, and of any pure breed. If the whites are related to the reds, the relationship is not so close, and you would have to go further back in the pedigree to find the common ancestor. But as we know that various special breeds have sprung from the same general stock of hens, we have good reason to believe that all hens are blood relations. Those of the same breed are closer cousins, those of different breeds more distant cousins; but all hens are cousins.

We can say the same of dogs or pigeons. We know, as a matter of breeding history, where and when the more recent breeds of these domestic animals originated; and we know that those of the same breed are descended from the same ancestors, and are comparatively close cousins, while those of different breeds are more distant cousins.

Now suppose we ask in an open-minded spirit whether pigeons are closer cousins to hens or to dogs. The answer can not be in doubt, once we allow the question to be put. Pigeons and hens have the marks of a common descent. It is quite easy to conceive of two similar species as being related species, once we carry over our knowledge of breeds to the larger and more distinct groups which we call species. Take the "cat family," including lions, tigers, bobcats, house cats and others. The more we know of their internal anatomy and of their behavior, the easier it becomes to believe them a real family, in the sense of being all blood relations. Extending this idea still further, we readily come to believe that all mammals are a family, and all birds another family.

We need, of course, to be on our guard against merely superficial resemblances between different sorts of animals. Penguins

and seals have considerable resemblance. The penguin doesn't fly any more than the seal runs on four feet; but they both swim and dive most expertly, and in a very similar manner. The penguin has flippers in place of wings, and the seal has them in place of legs. For all that, when carefully studied, the penguin is certainly a bird, and the seal a mammal. That means that the seal and penguin are by no means close relations. The seal is closer to the cat, by descent, and the penguin is closer to the hen. It certainly seems a sensible view, once you get the hang of it.

But if we have reached the point where we think of mammals as one immense, but genuine family, and of birds as another similar family, does common sense force us to stop there? Rather, when we come to know the fundamental resemblances between birds and mammals—in their bones, their muscles, their hearts, their brains—we are much inclined to believe in a fairly close relationship between birds and mammals, and indeed between all vertebrates, as contrasted with insects, molluscs or jellyfish. The whole animal kingdom seems made up of several great families, and probably even these are interrelated, if we could trace the ancestry back far enough. As regards plants, the whole idea could be developed there just as easily as in the case of animals.

One big doubt, however, arises. If all mammals, for example, are a true family of cousins, then should we not expect to find all gradations? Should we not be able with a complete collection of animals at our disposal from all parts of the world to arrange a zoo as a long row of cages, passing from the camel to the lion, for example, by small differences without a break anywhere in the series? As a matter of fact, a collection of living animals could not be arranged without leaving many large gaps. But then, ancestral breeds may have died out, leaving derived breeds in possession of the earth. This is not only a natural supposition, but is a fact, revealed by the fossil remains of the animals of old. The animals of former geological ages were not the animals of to-day. The horse as we know him did not exist, though horse-like breeds, that may well have been the ancestors of our horses, were then alive.

In considering the family tree of animals, we have to remember that the live species of to-day are the leaves on the outer twigs. We have before us, alive, only the outer shell of the tree. We can not see into the interior of the mass of branches; we can not see, directly, the past condition of the tree. We can partially reconstruct the past of the tree by laboriously digging up the remains of past seasons now lying buried beneath the tree, and piec-

ing them together as well as may be. In spite of the motley array of leaves which we now see on the outside of our family tree, we find, beneath the tree, good evidence that the tree was formerly more uniform than now, that many branches have died, leaving the rest to fill the space, and that all the branches have arisen from the same parent stem.

But does man fit into this scheme of things, and if so where? Well, there is no manner of doubt that man is a mammal. The more you know about his bones, muscles, blood, nervous system, the clearer it becomes that he belongs in the scheme. Nor is there any doubt as to his nearest living cousins; they are certainly the higher primates, the apes. Man is not descended from the chimpanzee, any more than the chimpanzee is descended from man, but they are leaves on the same branch of the family tree.

Fitting man into a place in the general family tree of animals is not humiliating, nor dangerous to morals. It does not lower man in the least; it leaves him just the same as before, with all his distinctive and remarkable qualities. A great artist may have very commonplace cousins, but he is a great artist just the same. Man's duties and opportunities correspond to his abilities and are not abated one whit by the fact of his having cousins less highly endowed. All that sort of objection to evolution is not commonsense, to say the least. If the brotherhood of all men is a humane conception, the cousinhood of man and animals is no less so. Once we see that man has an organic place in nature, we have a sense of being at home in the natural world that is a great satisfaction and, I believe, a great spiritual gain.

But, it may finally be asked, what does the Bible teach regarding evolution? It is fair to say that the Bible never raises the question, and consequently can not be expected to furnish anything like a direct answer. The answer, at the best, would have to be read into some passages by implication and would always be open to various interpretations. If anything is clear in reading the Bible, it is that we have here a religious book, a book concerned with man's religious life, and not with natural science. It is not a treatise on biology any more than a treatise on astronomy or chemistry or arithmetic. It leaves these fields entirely aside. How unfair to the Bible, then, how prejudicial to its continued influence, to lug it in and attempt to extort an answer from it on matters which it does not discuss and which lie outside of its chosen field!

FUNDAMENTAL FACTS IN THE HISTORY OF MATHEMATICS

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THE student of the general history of science can evidently not hope to become familiar with all the details relating to the history of the various subjects. Fortunately, some historical facts are very rich in implications, and the mastery of a few such facts constitutes an almost inexhaustible source from which the thoughtful student is able to deduce, with a fair degree of accuracy, a vast amount of well-coordinated historical information. In the history of mathematics such deductions are unusually safe in view of the fact that mathematics is based on a comparatively small number of postulates, and hence the mathematical routes, from the simpler to the more complex results, have, as a rule, not varied much, especially as regards the part of these routes within the domain of elementary mathematics.

There are few mathematical facts which are richer in historical implications than the so-called *Heron formula* for the area of a plane triangle. Millions of young students of mathematics have been pleasantly surprised by the fact that this area is exactly equal to the square root of the product obtained by multiplying together half of the sum of the sides and the three remainders obtained by subtracting from this half sum each of the sides separately. The great usefulness of this rule in land surveying is at once evident, and the difficulties involved in its proof are sufficiently serious to reflect great credit on the Greek mathematician who first proved it. One might at first be inclined to think that the ancient Greeks would have welcomed this proof with great enthusiasm and would have lavishly praised its author on many occasions, since this author reflected eternal glory on the Greek race. On the contrary, we find no evidence of such praise in the extant Greek literature. This literature does not even furnish any evidence as to who this author was. An Arabian writer of the tenth century stated that it was Archimedes, the greatest mathematician of antiquity, and modern mathematical historians are inclined to believe that this is correct. The scantiness of historical data relating to this fundamental rule is in itself rich in historical implications. The rule relates largely to practical applications of mathematics, and it is well known that the early Greek mathema-

ticians paid little attention to such applications. They studied mathematics with a view to securing intellectual penetration, and not with a view to finding results which are useful to the so-called practical people. That is, they studied *pure* mathematics rather than *applied* mathematics. It is true that we find some deviations from this general rule, especially in the works of Heron and some of the later Greek writers, but it is a fundamental historical fact that the people who made the greatest early advances in the development of mathematics took little interest in its applications.

While the scantiness of historical data relating to the fundamental rule under consideration is rich in historical implications, the fact that the rule was definitely proved at such an early date is still richer in such implications. The modern student of mathematics usually proves this rule for the first time in his first course in trigonometry. As the student of mathematics usually rediscovers a large number of results which were known before his day it is likely that this rule was rediscovered a large number of times, but we have no evidence that this was the case in ancient times. A more general but not quite accurate rule was used in India by Brahmagupta in the seventh century, and a new proof of the rule under consideration appears in an Arabian work written in 1036. The Roman surveyors also used this rule, but it is likely that all these peoples obtained it from the works of Heron, which were used widely either in the original or in a translated form.

We have here a definite fundamental rule relating to elementary geometry, which we now commonly express by the formula

$$\sqrt{s(s-a)(s-b)(s-c)}$$

where a, b, c represent the sides of a plane triangle and s represents half of their sum. Two interesting historical facts relating to this formula are that the ancient Greeks proved it but did not esteem it very highly and that it is of such an advanced character that notwithstanding its great usefulness the modern student of mathematics usually does not prove it before his freshman year in college. These two historical facts throw much light on the Greek attitude towards mathematics as well as on their advancement, for they could evidently not have proved such a formula without knowing a large number of more elementary theorems relating to elementary arithmetic and elementary geometry. The former of these facts also raises the question whether our modern emphasis on applications is most conducive to progress in science.

It is difficult to estimate the value of the wholesome influence of Heron's formula. It embodies an intellectual penetration of high order which doubtless has been a source of inspiration to many thousands of students. The facts that it is accurate and can be

easily employed, if the operation of extracting the approximate square root of a positive number is known, are significant. The former fact naturally appeals especially to the seeker of absolute truths, while the latter throws light on the meagerness of the mathematical insight of those who knew a rule which is equivalent to this formula but replaced it by inaccurate ones which require only rational operations. As an instance of this we may mention the remarkable fact that the Roman surveyors used also such an inaccurate formula as

$$\frac{a\,(a+1)}{2}$$

for the determination of the area of an equilateral triangle whose side is a. Mathematics practically from its beginning to the present time has been concerned both with accurate methods and with methods of approximation. In many cases it is impossible to determine whether the ancients who used the latter were aware of the fact that they led to results which are only approximately true. When this can be determined it throws much light on the mathematical insight of the people concerned.

A fundamental fact relating to the history of mathematics is that a large part of this history is necessarily based on secondary sources of information. This is especially true as regards the history of Greek mathematics. We do not even have the original of Euclid's "Elements," but the modern accepted texts of Euclid are based on various transcriptions. A rule equivalent to the formula considered above appears in various of the extant works of Heron, but all these are probably transcripts, and the proof may possibly be an interpolation. Hence the statement that the ancient Greeks knew and proved this rule must be regarded as one based upon secondary evidence, which is now commonly accepted by the specialists dealing with the history of Greek mathematics. This evidence is, however, less satisfactory than that furnished by the discovery of original works. In the case of Egyptian mathematics the work of Ahmes, written about 1700 B. C., furnishes evidence of the latter type. For more than three thousand years this work had ceased to influence mankind when in 1877 A. Eisenlohr awakened it by a translation into a modern language. It could then no longer instruct the world in mathematics, but it could and did furnish the world very definite information in regard to mathematical developments at the time when it was written.

One of the most surprising facts in the history of mathematics is the slowness with which negative numbers were generally adopted. Even the eighteenth century suffered from a lack of a satisfactory introduction of negative numbers, according to J. Tropfke, "Ge-

schichte der Elementar-Mathematik," volume 2 (1921), page 78. The modern student of elementary mathematics uses negative numbers extensively in his work in algebra, trigonometry and analytic geometry. Hence the fact that no satisfactory theory of negative numbers became generally known before the first half of the nineteenth century throws much light on the status of these subjects before this time. Even the founder of analytic geometry, R. Descartes (1596–1650), thought that negative numbers would increase as their absolute values increase and hence he must have had a very imperfect conception of the modern use of coordinates in analytic geometry.

The imperfect understanding of negative numbers by eminent mathematicians of comparatively recent times may be illustrated by the fact that the noted English mathematician J. Wallis (1616–1703), regarded them as greater than infinity in view of the assumption that by diminishing the denominator of a fraction with a constant positive numerator we continually increase the fraction even when the denominator becomes negative, as follows:

$$\frac{1}{4} < \frac{1}{3} < \frac{1}{2} < \frac{1}{1} < \frac{1}{0} < \frac{1}{-1}$$

At another place, however, J. Wallis stated correctly that positive and negative numbers are opposite just as profit and loss. The great Swiss mathematician, L. Euler (1707–1783), first noted that the positive and negative numbers are connected both at 0 and also at ∞. Contrary to what is sometimes stated this does not harmonize the earlier views that negative numbers are both greater than infinity and also less than zero, for the connection at infinity is not a continuous one.

Although no satisfactory theory of negative numbers became generally known before the first half of the nineteenth century it should not be inferred that we find no evidence of the successful earlier use of these numbers. The Indian mathematician, Brahmagupta, born in 598, placed a dot above a number to indicate that it is negative and another Indian mathematician, Bhaskara, born in 1114, used names for positive and negative numbers which correspond to our words of credit and debit. Indian mathematicians recognized also positive and negative square roots, but noted that "people do not approve a negative absolute number." In Europe negative numbers were used occasionally long before the legitimacy of this use was fully established, but some mathematicians were very conservative along this line. In particular the noted French mathematician, F. Vieta (1540–1603), did not admit negative solutions of equations. Even in the eighteenth century

some critical mathematicians like Robert Simson, of Glasgow, did not admit the legitimacy of operations with negative numbers.[1]

The history of mathematics concerns itself not only with the first use of certain fundamental concepts but also with the question when this concept came into general use. This question is frequently very difficult since later mathematicians did not always adopt promptly what was best in the work of their predecessors. In fact, the merits of certain mathematical work was frequently not fully appreciated until its influence on later developments became manifest. In the case of negative and imaginary numbers, for instance, it is not likely that those who first used them had a clear idea of the fundamental rôle which they were to play in the later developments of our subject. Mathematical historians seem now to agree on attributing the first satisfactory geometric theory of complex numbers to the Norwegian surveyor, Caspar Wessel (1745–1818), who published a memoir on these numbers in 1799. This theory did, however, not become generally known until much later, and various later writers may have developed it independently. In 1833 the Irish mathematician, W. R. Hamilton (1805–1865), presented before the Irish Academy the first satisfactory arithmetic theory of these numbers.

The fact that satisfactory theories of complex numbers did not become widely known before the latter part of the first half of the nineteenth century throws much light on the limitations of the mathematical developments which preceded this period. Hence such fertile facts should be grasped first by the student of the history of our subject. Similarly, the fact that no satisfactory theory of the solution of a general system of linear equations was possible before the latter half of the nineteenth century since the theory relating to the rank of a determinant was not developed earlier also throws light on the treatment of this subject in the earlier works. The fact that the French mathematician, A. L. Cauchy (1789–1857), is often called the founder of determinants implies that the earlier developments relating to this subject were relatively meager. In fact, in our freshman courses in algebra we often teach theorems relating to determinants which were unknown at the beginning of the nineteenth century. In particular, the rule known by the name of Sarrus for expanding a determinant of the third order by repeating two lines of the determinant was first published in 1846.

In view of the fact that in geometry many simplifications result from the use of the point at infinity it is interesting to note that in

[1] M. Cantor, "Vorlesungen über Geschichte der Mathematik," vol. 4 (1908), p. 80.

1609 J. Kepler (1571–1630) said for the first time as far as known that parallel lines meet at infinity, and that somewhat later G. Desargues (1593–1662) established the use of the point at infinity in geometrical work. The term *convergent* as relating to an infinite series appears also for the first time in the seventeenth century, *viz.*, in a work by the Scotch mathematician, James Gregory (1638–1675). Not only does the term convergent series appear in this work, entitled *Vera circuli et hyperpolae quadratura*, 1667, but the modern notion of the nature of such a series appears here more clearly than in any earlier work. The great importance of this notion in elementary calculus and elsewhere seems to justify the fact that we include its naming among the fundamental elements of the history of mathematics.

We shall also include among these elements the first use of imaginary exponents by L. Euler in 1740, when he communicated to John Bernoulli I the very interesting formula

$$2\cos x = e^{ix} + e^{-ix}$$

where $i = \sqrt{-1}$. This implies that all the earlier mathematicians confined their attention to real exponents. In particular, I. Newton could not have developed the binomial theorem for imaginary exponents and hence the common statement that he proved this theorem for the general exponent can not be accurate. What is more important to the mathematical historian is the fact that such an interesting formula naturally raised many questions as regards the use of imaginary exponents, and one finds in this fact an incentive to mathematical progress in the latter half of the eighteenth century. In particular, the need of a better understanding of imaginary numbers became more and more apparent, and this need inspired much of the mathematical progress during the latter half of the nineteenth century.

From what precedes it is clear that mathematics was not developed in the exact order in which we now present it to the student. Some of the things which we now commonly teach to the freshman in college were unknown at the beginning of the nineteenth century. On the other hand, even the ancient Greeks carried some of their mathematical developments beyond the point reached now by college students. A fundamental fact of the history of mathematics is that it is impossible in a general history of this subject to present a clear view of all the known developments. A general history must perforce make selections, and the most important principle in making these selections seems to be to exhibit first the most fruitful concepts. For instance, from the fact that negative and imaginary numbers did not receive general recognition before the beginning of the nineteenth century it is clear that the solution of the general

quadratic equation was not commonly understood before this time; and from the fact that the ancient Greeks did not use negative numbers it results that they could not have solved this general equation even formally.

It is customary to begin a study of the history of mathematics by considering first the contributions due to those who either made the earliest known advances in this field or who transmitted such advances. From the standpoint of securing well-coordinated historical insight into the development of mathematics there are many advantages in beginning with modern times. For instance, the fact that our modern method of studying a system of m linear equations in n unknown was first developed in the latter half of the nineteenth century throws much light on the work in linear equations during all the earlier times, and the study of this work will then tend to exhibit forcibly the advantages of the modern method and the advantages of living in the modern mathematical world. In fact, one may be led by such methods to marvel at the fact that the great mathematicians of all preceding ages failed to discover these methods, and to appreciate more fully their attainments, notwithstanding their handicaps. Those who study the history of mathematics mainly for the purpose of getting a deeper mathematical insight will usually find it most advantageous to begin with the modern developments of the subjects whose history they are tracing, since these developments are naturally easier and more complete than the older ones, and the elements which are imperfect in the latter stand out more clearly when they are compared with the former.

The history of science may profitably be regarded as an exposition of the compound interest law as regards the development of fundamental concepts and hence it is very important to secure a clear notion with respect to the early development of such concepts. The nature of the compound interest law may be partly illustrated by the fact that if instead of giving fundamental concepts to the church Christ could have safely invested one cent at 4 per cent. compounded annually for the benefit of the church of our day the amount would now be equal to more than the value of a volume of gold weighing many times as much as our whole earth. The value of his fundamental concepts to the modern church can obviously not be measured in terms of gold or in terms of what gold would buy. Similarly the value of the fundamental concepts of science can not be translated into material standards alone, even if the equipment of the modern American university might tend to suggest the possibility of such a translation. A proper presentation of the history of science should do much to counteract this tendency, as well as to exhibit the enormous cumulative effect of the fundamental concepts.

ANTHROPOLOGY AND THE ENDOCRINE GLANDS

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ALTHOUGH the influence of the sex glands, or, more properly speaking, of the deprivation of the reproductive organs, upon the individual characteristics of animals and human beings had been known for centuries, and although numerous pioneer observations and speculations antedated it, it was not until Charles Edward Brown-Séquard read a famous paper before the Société de Biologie of Paris on June 1, 1889, on the effects upon himself of injections of sex gland extracts that the far-reaching possibilities of a chemical mechanics of personality determination became manifest. Three years before, Victor Horsley, in England, had published a paper on certain "Functional nervous disorders due to loss of thyroid gland and pituitary body," in which an influence of these two glands upon the metabolism and condition of the nervous system was suggested. But the positive statement of Brown-Séquard concerning the effects upon various bodily and mental functions, such as appetite, physical strength, mental energy and ability to concentrate, channeled the territory for an ever-widening river of research and investigation.

Yet, although Pierre Marie published his observations on the effects of the pituitary gland in the disease acromegaly upon the bodily proportions, and Murray two years later, in 1891, published clinical observations on the personality modifications of the administration of thyroid gland, no attempt has come to my notice of the construction of a fundamental chemical theory of individuality for the next twenty years. In 1912, a German, R. Stern, published a monograph entitled "The bodily characteristics of predisposition to tabes" in which, basing his conceptions upon a careful study of individuals suffering from the diseases of the nervous system, locomotor ataxia and general paralysis, which sometimes develop in syphilitics, in which he definitely voiced the conception of a "polyglandular formula" as determining differences in form and function between individuals, as well as differences in resistance to disease and possibilities of infection. He compared different individuals with those suffering from thyroid and pituitary gland affections of their personality and declared that glandular differences in normal individuals could be deduced from variations in their morphology observable even in childhood and during adolescence. He

also emphasized that the variable contributions of the different glands of internal secretion to the make-up conditioned not only form and function variations, but also the receptivity toward disease and the character of disease as it developed. In the same year the Italian Nicola Pende read a paper before the Congress of Internal Medicine in Rome in which he compared various types of habitus with types established by glandular dominance and used the term "individual endocrine formula." As in the case of so many of the cardinal ideas of the sciences, it was as if a solution was waiting for some particle of disturbance to permit a great crystallization. Many minds all over the world were affected by the great conception of an endocrine-chemical determination of the anatomic and functional properties of human beings.

Dr. Joseph Fraenkel, who practised neurology in New York, contended and lectured for years that racial as well as individual characteristics were greatly influenced by the inherent glandular equipment, but published nothing. It remained for Sir Arthur Keith, in a now classical paper entitled "On the differentiation of mankind into racial types," to stress the significance of the newly emerging endocrine conceptions for the ethnic problems of anthropology. He stated that he believed there was enough evidence at hand to attribute the significant differences between the Caucasian, the Mongolian and the Negro races, the differences which the anthropologist used in their classification, to differences in the degree of functioning of the thyroid, the pituitary, the adrenal and sex glands. Using structural differences, as the relation of the trunk to the limbs and *vice versa*, pigmentation, hair distribution and other characteristics, such as the mode of origin of the nose and the character of its development, and comparing these with the known and apparent effect upon the same characters in clinical disturbances of the glands of internal secretion, he constructed a valid case for his theory. In 1921 Bolk presented his view in which he extended the theory of Keith, adapting it to a conception of his own which explained man's origin and deviation from the ancestral primates as an effect of certain endocrine variations and dominations. Particularly he stressed the conception of an inhibition, by glandular action, of the early maturation of various structural and functional characteristics, as explaining certain curious resemblances of adult man to fetal primate.

But besides the influence of the glands of internal secretion upon habitus and physique and such individual and racial qualities as skin texture and coloring, hair quality and distribution, cranial and facial bone development, therefore including head form, which is a primary interest to the anthropologist, the large issues of intelligence and temperament, as well as individual and racial vigor and vitality, come within the endocrine domain, as also does the me-

chanics of the appearance of those abnormal variants who have influenced the course of culture and history.

One of the great achievements of modern science has been the release of thought from the theological dogma, even now accepted as gospel truth by hundreds of millions, that the personality consists of the manifestations of a "soul," a reality which is made ot "spirit," opposed in its nature and activities to "matter," and consequently to the "body," palpably flesh and blood. In the past the scientific attitude had done good destructive work and paved the way for more rational conceptions. Not until quite recently, however, has it substituted any really satisfactory and useful data for those it demolished.

A number of thinkers of the seventeenth, eighteenth and nineteenth centuries evolved, partly out of their inner tough-minded consciousness and partly with the aid of the scanty knowledge at their disposal, mechanistic theories of human conduct. It was very bold of Thomas Hobbes in the seventeenth century to proclaim that the behavior of a man was simply the expression of his instincts. And the most daring of succeeding thinkers defied the gods in their heaven and the occupants of the seats of the mighty on earth when they declared that a man was just a machine. The substitution of the word "machine" for the word "soul" was a mental revolution. But it was an empty conception, because there was no concrete information at hand to supply the parts of the assemblage of the machine.

When Freud and his disciples appeared and showed that with the help of certain assumptions and terms a good many puzzling human reactions could be understood and riddles solved, there were those who shouted that a true mechanics of human nature was upon us. But it was not until the rapid accumulation of facts concerning the relation of the glands of internal secretion, producing substances which entered the blood and reached every part of the body with the blood, to the entire make-up of the individual, and especially to the nervous system, before birth, and during development, adolescence and maturity, that we may be said to have attained real knowledge concerning the basis of important practical variations in individuality.

It is easy to observe that a man can be studied from the standpoint of his physical traits. That different people can be classified as types on the basis of their bodily characteristics is a truism. It is also familiar that a classification of individuals is possible on the basis of mental traits, for every one speaks freely about character and character types. Many minds have suspected that there must be some relation between the physical traits and the mental. Physiognomy and phrenology, and even palmistry, were built upon the foundations of that suspicion. But the genuinely scientific

phase of consideration of a possible connection was born when it appeared that chemical substances, the internal secretions, provided specific, concrete, observable and measurable links between the body and the mind.

When the remarkable changes in the skin, hair, teeth, bones, as well as the emotional and intellectual status of a cretinoid idiot, were produced by feeding thyroid, who but would not wonder at the inevitable suggestion that here at last was available the long-sought chain between the manifestations of temperament and habitus? And when it was found that all the other glands of internal secretion, the pituitary, the pineal, the parathyroids, the thymus, the adrenals, the gonads, had a profound influence as energizers, activators, coordinators, harmonizers and regulators of all the vital processes (as facts turning up daily in both the laboratory and the clinic amply proved), who but would not wonder whether it was not in them that the secrets of personality were hidden?

True, the rôle of integration of the various parts of the body had for long been ascribed to the nervous system alone. Yet the fact could not be blinked at that, apart from vague ideas concerning the size of the brain layers, and still vaguer speculations concerning possible peculiarities of construction, the conception could offer not even a good working hypothesis to explain and explore differences in personality.

On the other hand, the internal secretions are chemical substances. It had long been accepted in the inorganic world that differences between substances are due to differences in the chemistry of them. If they were mixtures of more or less similar substances, the differences between them were ascribable to differences in the relative amounts of the components of the mixture. When it was seen that great differences in the physical and mental make-up and reactions could result from a variation in the amount of an internal secretion acting in an organism, the analogy was complete. One could imagine that individuals, like all other combinations in the universe, were mixtures of similar substances; that individuals were different because of differences in the amount of the substances entering into their composition; and that the most important of these substances were the internal secretions, because they, fundamentally, controlled the production, distribution and consumption of energy as well as the way chemical reactions should go in the various cells, including the nervous system. Observation confirmed up to the hilt these conceptions. It had long been known that many disturbances and changes and even diseases of the personality occurred without any observable pathology of the nervous system. On the other hand, *careful examination showed that no disease or disturbance of any of the glands of internal secretion happened without some corresponding and often striking change in the per-*

sonality. Excessive or insufficient activity of a gland could determine the type of physique of an individual. Overaction of the thyroid or pituitary, insufficient action of the adrenals or the gonads, for example, could produce the taller types of individuals. Conversely, overaction of the adrenals or gonads, or insufficient action of the thyroid or pituitary could produce the shorter types. On the psychic side, similar relations were evident. The challenging enthusiasm of the man with the over-acting thyroid contrasted sharply with the phlegmatic apathy of the man with deficient thyroid function. The hypersensitive melancholy of the man with the failing adrenals emphasized the virile driving quality of the man with sufficient functioning of the same glands. The incorrigible optimism of the individual whose pituitary and gonads are providing more than enough of their secretions stresses the effeminate, passive, rather sad and weak textures of the stuff of him in whom they are relatively lacking or under-secreting.

The introduction of the metabolic viewpoint in anthropology will, I believe, lead to great and immeasurably important results. The conception of a metabolic determination of organismal construction and functioning must needs throw a great deal of light upon the problems of interaction of organism and environment, as well as the problems of organismal groups, varieties and races, and the problems of individual variation and differentiation of body and mind.

It has been definitely established among the invertebrates, like the fruit fly, that the chromosomal constituents, more or less independently of the environment (although even here the necessity of a standard environment, so-called, has been conceded), are the fundamental determiners of individual characteristics. Apparently this is because among the invertebrates the substances in the chromosomes constitute the fundamental machine. Among the vertebrates, however, another apparatus becomes evolved. This apparatus is the system of the endocrine glands. The significant fact should be stressed that it is only among the vertebrates that the glands of internal secretion begin to exert an important influence upon the local and general metabolisms. Among the invertebrates most of them do not exist or only their homologues have been demonstrated. Moreover, the glands themselves undergo an evolution as one ascends the vertebrate scale, an evolution which points to an increasing influence upon individuality. No parathyroid glands have been found in fishes. In amphioxus the thyroid is a saccular organ which opens into the pharynx, and is lined by a ciliated epithelium which secretes mucus. According to Vincent, nothing corresponding to the adrenals has so far been discovered in amphioxus. And there is a well-known difference between the effects of extirpations of the

sex organs in invertebrates and vertebrates. In invertebrates, as, for example, certain butterflies, extirpation of the reproductive organs either experimentally or by disease is not accompanied by any change in the organism as a whole. In other words, there are no metabolic repercussions of the loss. In vertebrates the general bodily and mental effects of such an experiment are well known.

This last example may indeed be taken to exemplify the complete principle involved. In the invertebrates the chromosomal substances alone determine the architecture of the individual. In the vertebrates their influence becomes indissolubly linked with the action of organs which they themselves create, but which have in turn a modifying effect upon them. In the vertebrates, in fact, it may be stated that the chromosomal substances determine the production of local tissues and local tissue tendencies. The endocrine substances act either to exaggerate and stimulate or depress and inhibit these local tissue tendencies. From this point of view the chromosomes may be said to be local or regional factors, the endocrines may be contrasted as the constitutional or distributive factors. Two general laws may be deduced from the existing mass of evidence—which for lack of space can not be detailed here—concerning the relations of the chromosomal or regional and the constitutional or endocrine factors.

(1) The internal secretions are chemical substances influencing (catalytically as stimulants or depressants, interpretable as accelerators or retarders) local tendencies in cells, tissues and organs dependent upon local chemical reactions and physico-chemical conditions.

(2) These influences and relations are specific, that is, the character or intensity of effect depends upon a particular specificity in the internal secretion and the chemical substances under consideration, neither of which can be completely replaced by any other substance.

Now viewing individuals as the outcome of the specific interactions of these two sets of factors, the important principle emerges for the anthropologist that whereas the chromosomal factors are more or less independent of the environment and possessed of, as it were, a tremendous dynamic inertia of their own, the endocrine glands are indeed the mediators between the organism and the environment. In the adaptations of the organism to the environment, both developmentally and in maturity, they play a most significant rôle. By their correlations they produce those remarkable examples of covariations which have aroused the curiosity and wonder of all naturalists interested in the mysteries of adaptation.

What is environment? It would be impossible to name every detail entering into the composition of an environment. But we may say that it is first of all food, the various chemical elements in

their combinations necessary for the grist-mill of metabolism, Na, K, Ca, Mg, I, Cl, S, Fe, P, C, N, O, H, and certain other of the elements in their simpler combinations as well as the more complex ones such as the pyrrol ring. Then there are heat and cold, variations in temperature which affect metabolism. Then there is light, the peculiar influence of the infra-red as well as the ultraviolet rays, the effect of which upon metabolism have recently become the subjects of intensive research. There are electrical and electromagnetic conditions of earth and atmosphere. There are the influences of altitude, gravity and sea-level, with their concomitant variations in atmospheric pressure. . There are besides these physical and chemical factors, the psychic stimuli from living agents in the environment, friends, enemies, associates, sex and so on.

All these physical, chemical and psychic environmental factors act upon the glands of internal secretion, which are sensitive to them. Through their interaction, the function of a gland may be stimulated to the point of relative overactivity or depressed to the point of underactivity, within the physiological limits. Beyond these physiological limits lies pathology. But within them range a series of values which all come within the limits of the normal, but which are responsible for many of the differences perceivable in any group of so-called normals or between different normal groups.

The thyroid, for example, is most sensitive to the iodine content of the environment. When the iodine content falls below a certain minimum there develops goiter, accompanied generally by insufficiency, but sometimes by overactivity of the gland. That in turn influences the metabolism of every tissue in the body and especially the metabolism of the nervous system. A certain adaptive mobility of the metabolism, its ability to adapt itself to heat and cold changes, temperature variation, depends upon an adequate balanced function of the thyroid. The thyroid itself may be affected adversely by heat and cold, with retrograde effects upon the organism as a whole. Heat or cold acting for generations would be bound to leave its mark on the thyroid.

The parathyroid glands, which affect the sensitivity of the nervous system like the thyroid, but with a reversed effect—thyroid hyperfunction increases the sensitivity of the nervous system, while parathyroid subfunction also increases it—seem peculiarly sensitive to the calcium and phosphorus content of the environment. When there is an insufficiency of these, they hypertrophy. They regulate calcium and phosphorus metabolism in all the cells with profound influences morphologically and physiologically. They are probably also sensitive to light, particularly to certain regions in the ultraviolet portion of the spectrum which influence calcium and phosphorus metabolism. We know that the amounts of these ultra-

violet rays playing upon the earth vary during different seasons of the year, and in different localities. We may, therefore, legitimately ask: How much of local group and racial differences may be traced to parathyroid differences, depending in part upon variable calcium and phosphorus intake continued for generations and in part upon variable ultraviolet ray exposure during the same period?

As a matter of fact, one manifestation of such an influence was first discovered and described in 1921 by Krogh and the Jaensch brothers in Marburg, Germany. They have named the manifestation the eidetic phenomenon. The phenomenon consists of the following: There are certain children who have the capacity to recall at will, including every detail, which they can describe most vividly, scenes or pictures, maps or diagrams they have once viewed. This eidetic capacity is not the type of visual recall which is called visualizing and is sometimes spoken of as "seeing with the mind's eye." It consists in seeing, to the very last detail of design and color and at the distance at which it was originally viewed, all the spectacle once presented to the eye. It was found that feeding lime and cod-liver oil could cause complete loss of the capacity, to reappear when the lime and cod-liver oil is stopped. I have applied the methods of Krogh and Jaensch in the investigation of a number of children in several schools in New York and found a considerable percentage of such children. Those who had stigmata of the parathyroid deficiency—that is, those who were not capable of assimilating lime properly—responded to the feeding of lime and cod-liver oil by loss of their peculiar gift. They are by no means conscious of the possession of any unique or abnormal faculty, indeed believing that every one enjoys it. It is most frequent in children between the ages of five and seven, decreases in distribution as the children grow older, and is only rarely found in an adolescent.

The environmental factor to which the pituitary gland is sensitive, is, as Keith in particular has emphasized, the factor of mechanical stresses and strains. Occupation, therefore, but also other mechanically acting agencies, will affect parts of the body sensitized by the anterior pituitary hormone. In anterior pituitary hyperfunction, we see bony overgrowth at points subjected to the greatest mechanical stress. The posterior pituitary has to do with the metabolism of fats and carbohydrates. Groups of individuals who subsist for a long period of time on a diet consisting largely of starches or fats should be investigated from the standpoint of posterior pituitary functions. Body pigmentation is also connected with the pituitary gland function, and should be considered as well as the cortex of the adrenal glands in any research into the question of racial pigmentations.

Accumulating evidence has established that the adrenal cortex gland—or as some call it—the interrenal gland—is an antagonist, a sort of balancing wheel to the thyroid. Clinical considerations had long made possible the inference that while the thyroid accelerates metabolism, the adrenal cortex retards it. The recent work of Marine and his collaborators has confirmed this inference. All the environmental influences which affect the thyroid may therefore indirectly influence the adrenal cortex. As the latter is also involved in the mechanics of skin pigmentation, hair development and distribution as well as sexual differentiation, the possibilities become manifest of correlated variations because of adrenal—cortex—thyroid imbalance.

Both the adrenal medulla and the thymus glands are sensitive to the vitamin intake. The work of Riddle points to an implication of the thymus in lime metabolism. In spite of much experimental evidence, clinical considerations point to an importance of the thymus in growth and development and in response to the environment. Adrenalin, the secretion of the adrenal medulla, is of the greatest importance in what might be termed the excitement concentration of the environment. Its functioning is the now classical example of interaction of the endocrine system and the nervous system in adaptation to the environment. The sensitivity of the gonads to the physical and chemical agencies in the environment remains to be completely investigated. But the influence of long-continued use of aphrodisiac foods may be suspected. Variation in sexual differentiation and activity in different geographical groups will have to be studied from this viewpoint.

The great variability and sensitivity of the endocrine system introduces a new series of factors and a fresh angle of investigation in the long-mooted questions of the relations of the individual and the environment.

The nervous system is most sensitive to the psychic contents of the environment, the endocrine system to the physico-chemical contents. Both, however, interact to produce variations in individuality. Inspection of the results of such interaction, particularly the results of endocrine dysfunction, can not but drive home the far-reaching significance of endocrine relations to the environment and the nervous system in racial and group investigations. No one is more aware than the writer of the limitations of our knowledge of the endocrine glands. But it seems to him manifest that in the explanation of similarities and dissimilarities in racial and geographical groups, their investigation opens the road to a series of researches the value of which can not be overestimated. Research, however, must be preceded by a conceptual viewpoint and imagination.

THE WHALER AND THE TORTOISE[1]

By Dr. CHARLES HASKINS TOWNSEND

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THE Elderly Whaler and I sat in front of the Old Doelen at The Hague smoking, enjoying the long summer evening and discussing the day's proceedings at the Court of Arbitration.

At the afternoon session I had made some statement relative to the extermination of fur seals at the Galapagos Islands, which moved The Whaler to talk about his voyages in that part of the Pacific. The fur seals had about disappeared in his "day," but the whaleships were still calling at the islands for supplies of tortoises just as they had been doing for sixty years or more.

When he found that I too had been there in search of tortoises his reservoir of reminiscence began to overflow. We pulled our chairs farther out on the wide brick pavement away from the chatter about the entrance and took turns at tortoise hunting until the belated stars came out.

The next evening after some preliminary harpooning of "sparm" whales, I managed to put the helm over and we made the islands again, it being my turn and tortoises more in my line just then than whales. It was in '88, I told him, that the *Albatross* cruised there and finally sailed with eighteen of the long-necked and hard-shelled "galapagos" wandering about the deck, one of them big enough for the sailors to ride. When I went there again in '91 we found only one. They are all now in the National Museum, victims of their first northern winter.

But my tortoises were no match for his three-hundred-pounders. So I filled my pipe and contentedly settled down to learn about those of his day, when some of the giants like those described by the early navigators were still to be found. All the "blubber hunters" cruising in the eastern Pacific went to the Galapagos Islands to load up with tortoises, mostly those small enough to be carried on a man's back, weighing say seventy-five pounds.

When larger tortoises were taken they were slung on whaleboat oars and toted by two or even four men. Sometimes a really big

[1] The New York Zoological Society will shortly publish a lengthy account of the giant tortoises of the Galapagos Islands in their relation to the whaling industry of the nineteenth century. It is based on the hitherto overlooked records of the whaling fleet as contained in many logbooks recently examined by Dr. Townsend.—THE EDITOR.

galapago, when found near the beach, was overturned and dragged by ropes tied to his legs. All the larger islands had tortoises, and whaleships might stay a week or more to lay in a supply. They required no food or water and lived on the decks for months.

The Whaler knew them as terrapin, in distinction from the long-flippered sea turtles, but always called them "turpin." My inquiry as to whether they were really as good eating as all the early navigators had claimed brought forth a most emphatic affirmative. There was *no* better eating than turpin, and as for turpin liver, when he was before the mast he noticed with great depression of spirits that most of it went aft to the cabin. But he had experienced its heavenly delectableness both then and later on when he occupied the cabin himself. Turpin fat was almost as wonderful. It made the very best of shortening. They took some of it home to the housewives of New Bedford and Nantucket, who pronounced it superior to anything known for that purpose and wished they might have more of it. Whaleships weren't as a rule oversupplied with high-class provisions. One Christmas day at sea he had doughnuts fried in turpin oil, the bright memory of which remained untarnished after half a lifetime.

The Whaler said that sometimes three or four whalers would anchor at an island and send men "turpining" from a camp on the beach. Men often got lost, and it took a lot of time to find them. More rarely a man that had wandered too far into rough country and got lost among the deep gullies and cactus, or was laid out by the heat, couldn't be found at all and had finally to be abandoned. There were cases where lost Crusoes, if they had succeeded in finding water, were picked up by other whalers after weeks of solitude. There were things ashore a man could eat, but he'd be "a sight" by that time. They always took water ashore. It was hard going for the turpin hunters over the terrible volcanic country. Didn't I find it so? I related my experience: One day I found a fifty pound tortoise a mile or more inland on Duncan Island and at an elevation of five or six hundred feet. It was past noon and my canteen had been empty for an hour. The heat could be described in nothing but superlative terms. I dreaded a return by the fearsome, cross-gullied route struggled over going in, but it seemed risky to seek a better one out with the handicap of a clumsy burden. The tortoise slung on my back by his legs exhibited signs of discomfort that did not lessen my own and the sling ropes fairly cut into my shoulders. Nevertheless it had to be carried. In my late day a Galapagos tortoise had become a rare natural history specimen, too valuable for any naturalist to abandon under any circumstances.

The bad going was the real barrier to progress. There was no sign of a trail and no straight course at any time for more than a few yards. There were patches of cactus, thorny shrubbery and broken lava blocks of uncertain balance to be avoided at every turn. There were missteps that did my shins no good, but hob-nailed shoes helped to save the situation. The general direction offered no problem, although the ship had been out of sight since eleven o'clock.

It was a course of difficult descents into hot narrow gullies, with more difficult ascents that necessitated frequent rests on the sharp ridges between them. When, after a course so necessarily devious that the distance was doubled or trebled and the ship finally located, the burden could be supported no longer. Securing the unhappy tortoise by one foreleg to the swaying branch of a tough bush and marking its position with the most of my shirt raised on the longest stick that could be found, I set out for the rocky shore a quarter of a mile farther down. Thirst, which was now approaching the maddening point, drove me into the sea, sweated clothing and all. This served at least to lower the temperature until the dinghy came. The boat's breaker being empty, the sailors put me aboard the *Albatross* for water before going for the tortoise, which they did not get down until sunset.

I suggested that possibly my tale of a tortoise hunt told after the lapse of years might be a composite of experiences on several islands, but The Whaler agreed that the difficulties of Galapagos travel were none the less real. Had it been otherwise, the supply of tortoises could hardly have lasted, as it did, throughout the long period of whaling activity.

One evening The Whaler and I drove to Scheveningen and after dinner at a big hotel sat watching the moonlight on the surf. I was still eager for the information he possessed and led the talk back to the subject of the tortoises for which the Galapagos Islands are chiefly celebrated, and whose mysterious origin and development on uninhabited volcanic islands have fascinated and puzzled all naturalists.

Darwin saw them in the days of their abundance and wrote by far the best account of them. I had carried Darwin's "Voyage" to the islands and The Whaler said he would read it when he got back to New Bedford. The Whaler got to the tortoise islands a quarter of a century after Darwin, but yet a quarter of a century ahead of me and saw things that I arrived too late to see. Many of the early navigators who went there in the seventeenth and eighteenth centuries wrote accounts of the tortoises and how they had carried them away by the hundreds. I had looked them up to some extent before going there myself, but I had never realized the

importance of the tortoises to the great whaling fleet of the nineteenth century. It was known in a general way, but had, strangely enough, never got into the books. The Whaler told me there were hundreds of vessels in the fleet at one time. While they didn't all go to the Galapagos or even to the Pacific, those that did so made repeated visits to the islands. It was their rendezvous for the wonderful turpin food that could be had for the taking. There was a great advantage in turpin meat in provisioning a ship. It could be had fresh any time at sea, provided they got plenty of them. It didn't have to be pickled, and nobody ever got tired of it. They took on board all they could get without too great delay—sometimes a hundred or more. Some ships that didn't expect to return that way took twice that many. The turpin lived in the hold among the oil barrels just as well as on the deck. The Whaler knew of some that lived more than a year and seemed to be as fat as ever. Certain skippers had in fact taken them to the home port and turned them out to grass, where children rode on them.

I told him that Porter, whose warship drove the British whalers away from the islands during the war of 1812, wrote of taking on board between four and five hundred tortoises at one time. The Whaler thought that likely enough, as the older skippers of his day often said, there were thousands of them even on the smaller islands along in the thirties and forties. Some of them were of enormous size. He had heard of two or three up in the mountains of Albemarle Island too big to be moved, that had dates cut on their shells as far back as sixty or seventy years. The whalers who had seen them thought they might weigh seven or eight hundred pounds, but this he was disposed to question until I told of the great tortoise of Aldabra Island in the Indian Ocean that was known by naturalists to weigh over eight hundred pounds.

My personal experiences on the Galapagos, which I had visited twice, had resulted in the acquisition of considerable tortoise lore and I held my own with The Whaler fairly well, considering that I had merely gathered up the rare and scattered remnant of the tortoise legions on which he and his ravenous crews once feasted high.

There weren't many turpin left after his day, he supposed. The whaling business didn't last much longer either. Petroleum had been discovered, which ruined the price of whale oil, and the Civil War with the seizure of many vessels just about finished it.

I turned the talk back a couple of centuries: The early navigators had put on record a great deal about the tortoises and their marvelous abundance. They also did their share at carrying them away. Dampier, who saw the tortoises in 1684, said, "It is incredi-

ble to report how numerous they are." Little is known of what the buccaneers and the sealers who followed them did to the tortoises, and there are but few records of the hundred years' toll taken by passing merchantmen. The whalers that finally came to gather the cetacean harvest of the Pacific outnumbered them all and continued the decimation that had been going on for two centuries. Dr. Bauer, a naturalist who went to the Galapagos in 1891, thought that ten millions of tortoises might have been carried away from the islands since their discovery. The part of the whalers in the destruction was known vaguely, but no one had searched their logbooks and assigned them a definite place in the history of tortoise extermination. This, I reasoned from The Whaler's talk, was something that should be done and some time later I set about it in earnest. Among the logs examined in certain old whaling ports, I found seventy-nine belonging to vessels that had visited the Galapagos at various times between 1831 and 1868 and had carried off thirteen thousand tortoises.

This afforded a measure by which to gauge the effect produced by the fleet as a whole, which once numbered over seven hundred vessels. Moreover, the limited number of logs discovered were those of American vessels only. What tortoise history might lie concealed in those of Great Britain and other countries formerly engaged in whaling about the Galapagos could only be conjectured.

The extracts from the logs supplied data respecting tortoises that had previously been lacking, giving not only the dates and the separate islands visited, but in most cases the numbers of tortoises secured at each. As each island of this anomalous archipelago bore its own particular species of tortoise, the most of which are now extinct, the logbooks of the whalers furnished new information on the progress of the work of extermination. According to these records, tortoises were taken from nine islands of this group, the smaller and lower islands being the first to be stripped of their stocks of tortoises.

Albemarle, the largest, with a length of seventy-five miles and elevations up to five thousand feet, continued to yield tortoises to energetic whalers long after they had become scarce elsewhere. Some vessels made large catches especially in the thirties, the ship *Isabella,* of New Bedford, heading the list with 335, taken at Hood Island from December fourth to eighth in the year 1831. The ship *Hector* took 237 at Charles Island in December, 1832; the ship *Lima,* of Nantucket, 224 from James Island in 1837, and so on.

Here are the quaint log entries on tortoise gathering from three of them, and most of the seventy-nine are quaint enough. I found that all the whalers called them turpin.

Ship *Abigail,* of New Bedford, at Indefatigable Island in 1834:

May 15 steering for Porter's island [Indefatigable] 4 PM came to anchor in Downes Bay in 7 fathoms
May 16 Boats came on Board with 21 large turpin
May 17 Boats came on Board with 31 turpin
May 19 Boats came on Board with 40 live turpin
May 22 the Boats Returned with 40 live turpin we got here 140 Terepin

Ship *Bengal,* of Salem, at Charles Island in 1834:

Mar 22 at sunset arrived on board the boates got 50 turpin larg an small, Mar 24 at 4·AM all the Boates whent a boute 12 miles to——N W point of the Island after anchoring the Boates we landed on the rocks and by the help of a rope we succeeded in getting up the precipice we found a plain with some large terrapin on of which & Backet to the Boates——we got 50 turapin

Ship *Barclay,* of New Bedford, at Charles Island in 1835:

July 15 at daylight sent 2 Boats for Turpin.

July 16 at 6 Boats returned with 20 Turpin.

July 17 2 boats a turpining——three of the men Deserted Caleb Halstead Alfred Overtwin Ron Blanchard the boat returned without them at 7 oclock the Boats Returned with 30 turpin.

July 18 caught the three Runaways put the Ringleader Caleb Halstead in Irons and kept him Below the *Gideon Basto* [*Barstow*] Left and the ship *Washington* and *Balcaner* of New Bedford Arrived

The *Barclay* was an old-timer, having made her first voyage in 1795.

But I have gotten far away from The Hague in telling about what I learned much later from the logs. The Whaler was wondering how the turpin got there in the first place, the crater-covered islands, one of them with a living volcano, lying five hundred miles from the mainland. The best I could do was to give him a choice of theories. A few naturalists were inclined toward a theory which presupposed a former land connection with the American continent. This would require, as Milton says, "a bridge of wond'rous length." Moreover, there were ocean depths of two miles between that had to be considered. I was impressed with these depths, having participated in the sounding of them. A simpler and more acceptable theory was that of distribution by currents and winds. The islands, extending through a hundred and thirty miles of latitude, lay across the paths of the prevailing westerly winds and currents. Their position was such as to favor the accumulation of drifting objects. With such conditions prevailing through a long period of time, various forms of living flotsam from the mainland could not have failed

to arrive there. The hardy tortoise, able to live for months without food or water and able to float, would have as good a chance to survive the voyage as the lizards or any of the early involuntary immigrants that had no power of flight. The Whaler and I had both seen plenty of drifting trees that could support animal forms and both of us had experienced the force of the currents setting toward the Galapagos. While there was no evidence that the islands were known to aboriginal man, there was also no evidence that he had not been there temporarily and taken a few mainland tortoises with him. The mainland tortoise was still to be found in abundance no farther away than the Isthmus of Panama. Although seldom more than two feet in length, it differed little more from the average Galapagan animal than did the various island forms of the latter from each other. If not their ancestor, it ought to be at least their first cousin.

When The Whaler's work was done and he had left for home, I am bound to say that I missed him. I have ever appreciated competent seamanship. Besides, he had given me the clue to the missing later history of the tortoises that I then and there determined to follow up. The logbooks of whaling vessels ought to contain records bearing on the long work of extermination that was now so nearly completed. Years later I went to New Bedford in search of them. My fine old whaler had gone where there are neither ships nor whales, except for Argo and Cetus in the starry vault overhead. What he had told the august arbitrators at The Hague from time to time about the business of whaling, they had never been disposed to question. So I observed in going over the scrawled and stained logs discovered at New Bedford and Salem and Nantucket that what he had told me about whalers and giant tortoises was verified in all the records that I found.

THE HUMANIST AND I[1]

By Dr. PAUL R. HEYL

THE BUREAU OF STANDARDS

MY friend the Humanist has just been in to see me and we have had a royal good time together. It included our customary quarrel. No such occasion would be complete without that; we have been doing it so long. It started in our junior year in college, when we were called upon to make for the first time an election of the courses we proposed henceforth to follow. He chose the humanities and I the sciences.

I well remember how upset he was when he first heard of my decision and what he said about it. "And thou too, Brutus!" Of course he used the Latin for it. Anything else would have been beneath the dignity of a scholar of twenty. I started to reply appropriately, using good Shakespearian English. I got as far as "Not that I loved Caesar less," when he cut me off impartiently.

"Nonsense; I'm not worth considering. It isn't that; it's what you are giving up and what you are giving it up for. What has come over you?"

"Good gracious, my dear fellow!" I said. "Why do you take it so hard? I'm not electing a life of crime; I'm only going in for the sciences. Why not?"

"Yes," he said, somewhat more calmly. "I know the usual argument. Somebody has to do it. Our civilization is going to be more and more dependent upon the development of the sciences. And it's all true. But leave that to people who can not do anything else. Come back, and go with me!"

We had more argument back and forth on the matter which touched no vital point, but merely blew off steam, and we finally were each of the same opinion as at the beginning.

I felt a little hurt by his attitude. The sciences seemed to me to be equally as respectable as the humanities, only, of course, they had not as long a learned pedigree. They lacked the authority that tradition might confer. Such tradition as was theirs was even against them, for had not our sciences descended from such forbears as alchemy, astrology and black magic, practiced, oftener than not, by quacks and charlatans? But, equally, some of the

[1] Published by permission of the director of the Bureau of Standards of the U. S. Department of Commerce.

greatest humanists of old times were little better. Had not we read together, in our sophomore English, of Browning's bishop, ordering his tomb at St. Praxed's, with his love of good Latin, and "brown Greek manuscripts," with his exquisite taste in stone and sculpture, all superposed upon a personal character of an intolerable type? And had not the instructor quoted Ruskin to us as testifying to the accuracy of Browning's picture, saying that this short poem more truly and completely expressed the soul and body of Renaissance culture than all he himself had said in "The Stones of Venice"? And then, too, I knew that my friend was not ordinarily attracted by tradition and authority, that he set small store by pedigree and family tree, and that he had always chosen his associates for their own values. No, it must be that he held the sciences in low esteem on their own merits, and why I could not see, nor could I get him to specify.

I suspect now, after thirty years, that my friend was not exactly clear on that point himself, that his feeling of repulsion was largely subconscious and instinctive. Be this as it may, he held to his opinion and I to mine. Years, and the larger experience of life which they bring, have in some measure clarified the situation. In our perennial arguments we have been able to give each other more of a reason for the faith that was in us, yet neither has been able to convince or convert the other.

I once tried to tease him by saying that his dislike for the sciences was due to the exactness of thinking that they required, but I did not get very far that way. He parried that thrust easily, and without feeling it necessary to defend the humanities in that respect. "No," said he, "In some things exactness of detail is called for; in others it is an artistic fault. Consider the oil painting; by their reactions to it ye shall know them, whether novice or connoisseur. To the former the crudeness of detail is the most impressive feature, while the latter, at the correct distance, is unconscious of it."

And I suppose he is right. Where should we be without those who possess the great gifts of intuition and perspective? Did Shakespeare acquire his knowledge of human nature by a study of the psychology of behavior?

My friend's real aversion to science and its works and ways seems to be something else, something with which one must feel sympathy; a vague fear lest the scientific attitude of mind, logical in season and out of season (for there is a closed time even for logic), always schematizing, ordering, classifying, house-cleaning, putting things uncomfortably to rights—a fear lest all this leave no room for freedom of the spirit, spontaneity of mind or for the

priceless intangibles in general. It is the same sort of instinctive dread which the spiritually minded man may feel for the atheist; a fear lest he shall have taken from him something which he holds most precious and lest his outlook be reduced to an intolerable grey monotony.

Such regard I, an insider, have never felt that scientific men have deserved. I have learned that the pursuit of science demands imagination to a degree which few persons are fortunate enough to possess. The better poet, the better man of science; and I can prove this by the evidence of the poets themselves. The hushed awe of the Psalmist before the starry heavens; the flower in the crannied wall, sending down its roots deeper than did ever plummet sound; the solemn organ tones of Thanatopsis, telling how Nature answers in a varied language, now gracious as a queen's greeting, now inscrutable as the Sphinx—what are these but recognition on the part of the poets of the essentially spiritual and artistic quality of the subject-matter of science? And if the world has gained the impression that science is grim, whose fault is it?

Ours, of course, we high priests and prophets of that faith; but it takes usually many mellowing years before one can see this. I suppose that in my green olive days I contributed my share toward this general impression, and I do not now blame those who seemed disinclined to acquire the taste for the unripe article. But advancing years should have softened the high intolerance of youth in my friend the Humanist also; and this is now my principal quarrel with him.

I think, however, that I made rather a dent in his armor this evening. Looking over the books the other day at a second-hand stall I found a volume of essays. One of them was on "Sun Worship." In its pages my eye caught something. "Ammunition!" I said, and took the book home with me.

I admit that I set the stage when I knew my friend was coming, but I plead the end as justifying the means. When he entered I had open before me a certain book at a page containing the maximum number of mathematical symbols that I could find. He cast a rather contemptuous glance at it as he sat down.

"Come, now," I said. "You are not fair. You did not let Greek characters keep you from the thought that was behind them; and I do not think you would turn up your nose even at a page of Arabic if you thought there was something worth while in it. You might regret your unacquaintance with Arabic; in your ignorance of science you glory. This contempt for the language in which my books are written goes too far. Your attitude, old fellow, carries

with it an implied insult to my intelligence as a student of such matters."

He grinned at me in return.

"That's just what has puzzled me all these years. What is there behind these cabalistic runes that could interest a certain young fellow I used to know?"

For answer I pointed through the window at the sinking sun. He looked bewildered. "Come," I said, "Let me translate for you." And muttering under my breath, like Huxley, "The Lord hath delivered him into mine hand," I took down my recently acquired ammunition and read to him from one of the pages:

THE PSALM OF THE SUN

Bow down, O my children: even worship me, ye men of wisdom!
As I rise upon you, and ye greet the morning: humble yourselves and be thankful.
For all that man possesseth is of me: and what hath any man that I have not given him?
Should I withhold my glory from the fields: or should I turn away from the watery mirrors,
Where then were the fruit of the earth: and where the dew of the morning?
Therefore rejoice, O my children, in my bounty: and bathe yourselves in my glory.
As I rise upon you and ye greet the morning: humble yourselves and be thankful!

He was silent a moment; then he picked up the book lying on my desk and looked at it. The title of the chapter was "The conservation of energy." On the fly leaf he saw my boyish signature and the date—our junior year in college. He looked at it for several moments; then he laid the book down (rather carefully, I thought), saying:

"And they never told me!"

RADIO TALKS ON SCIENCE[1]

COAL

By Dr. DAVID WHITE
U. S. GEOLOGICAL SURVEY

COAL is like character; the deeper you go into it the more interesting it becomes, and there is much in it that, unsuspected, is beautiful. Ordinary bituminous coal is dirty, black and uncouth, and anthracite is none too clean; but if you cut from a lump of coal a slice thin enough to be translucent and examine it under a microscope you will see what beautiful things coal is made of.

The preparation of such a thin section is a most delicate task. First, a thin flat piece from a lump is sawed out and then ground down smoothly until it is reduced nearly to a film—that is, until it averages about two ten thousandths of an inch in thickness. This thickness—or rather thinness—would correspond to the leaves of a book in which fourteen thousand pages make a volume only one inch in thickness. The thin slice of coal is then mounted on a thin piece of glass for study.

Seen through the microscope such slices of coal are found to be translucent, and if treated with certain chemicals before grinding, they will be so beautifully translucent that they may be examined by a microscope which magnifies them more than eighteen hundred times.

Under the microscope the coal is no longer dark as night, or sooty, or forbidding. In the cross-section of that dirty lump one beholds a landscape in brown and gold. Golden links in serried chains bound in filigree fill portions of the view. The links are the cross-sections of the cells of pieces of wood of twig, branch or log that enter into the product we call coal. Each cell in the wood is a jewel box of gold. In the hollow interior where once were protoplasm, starch and other substances embracing the very life of the plant, we find a transparent amber-like substance clouded with sepia and containing clusters of shining crystals of utmost minuteness, together, perhaps, with tiny glistening globules of gas. Stem of leaf and fern and scale of catkin or cone are seen in tissues traced in saffron and orange, straw-color and russet. Scattered

[1] Broadcast from Station WCAP, Washington, D. C., under the auspices of the National Research Council and Science Service and the direction of Mr. W. E. Tisdale.

here and there are a thousand spores of club moss, fern or fungus, and pollen of many kinds of flowers, now appearing as ovals, clasps and crescents of luminescent brass or antique gold. Festooning skeins in brown, knit with silver representing cross-sections of fragments of inner tissue of leaf or bud are perhaps present; and resins of different kinds, brownish, amber, yellow and red, stud the pattern like precious stones. Real amber used in jewlery is, you know, a fossil resin. Yonder mesh of old gold sealed over with a mosaic in glistening topaz-yellow is a piece of the outer wall of a leaf. The fragile labyrinths traced in pale yellow and silver are the cross-sections of fragments of "mineral charcoal," the so-called "mother of coal." The scene changes from area to area and from specimen to specimen.

All these details of tracery and mosaic are set in a background—the ground mass—of cinnamon verging into sepia and brownish black, which fills the spaces. This composes the dark shadows of the picture.

All this vegetable débris which we see under the microscope corresponds exactly to that which we know as peat as it is formed to-day in some peat bog; and though this débris in coal is now fossilized and its chemical composition is greatly changed, it does not differ either in structure or nature from common peat. In fact, the close geological as well as the microscopical study of coals proves that all the ordinary kinds of coal, including anthracite, began their existence as peats deposited in vast swamps that once spread back of the low coasts, or in the interior lowland basins of the continents in ancient geological times.

These ancient peat swamps were usually covered by forest growth, and the coal beds, as we now find them, are generally underlain by old soils in which the roots of trees and smaller plants are still seen where they grew. Most of the swamps were very shallowly covered by water during parts, at least, of the year, just as now are the great peat swamps of the south Atlantic states. The botanical evidence points toward mildness of climate with ample rainfall, especially when and where the earlier coals (peats) were laid down in the Appalachian coal fields.

What we see under the microscope, namely, wood fragments, twigs, leaves, seed coats, spore cases, etc., now chemically transformed in colors of gold and brown, are, of course, the plant débris that was saved from decay by the germ-poisonous products developed by bacteria at or near the surface of the peat on which this débris was deposited. Decay, largely the work of the microorganisms themselves, ceases in the peat. Many of the plant compounds, including the protoplasm in the cell cavities, were broken down by

the bacteria at time of deposition. Most of the delicate tissues and even portions of the wood generally underwent more or less decomposition—that is, chemical change—in this process. However, the great chemical and physical transformations by which the peats were changed to coals of successively higher ranks—*i.e.*, lignite, sub-bituminous, bituminous, semi-bituminous (or smokeless coals) and anthracites have been brought about by geological processes instead of by bacterial action. The principal agents in the geological transformation are pressure, heat and time.

The pressures taking part in the conversion of peats to coals of different ranks are, first, the downward pressure or weight of hundreds—perhaps many thousands—of feet of beds of sand, mud, limestone, etc., piled on top of the peat bed as the region was sinking or the basin was filling. Second, and far more effective, however, are the horizontal pressures which cause great lateral compression of the rocks, and in certain regions produce buckling or great wrinkles in the earth's crust—*i.e.*, the building of mountains. Pressures overcoming the strength or rigidity of the strata of the crust cause breaking and faulting, as well as buckling. Continued thrust ramming after the strata are broken or highly folded drives the beds on one side across the broken edges on the other side and onward in a great overriding wedge or overlap. Such overthrusts are unnumbered. They date from different geological periods and occur in many regions, and some are now in progress. In Glacier National Park, Chief Mountain is carved from a great overlap of very ancient beds of limestone that have been shoved eastward at least ten miles over on top of soft Cretaceous rocks that were formed more than two hundred millions of years later than the limestones. The entire Cumberland coal basin of southwestern Virginia and northern Tennessee has been driven several miles westward on to the eastern Kentucky coal field. Arthur Keith, of the U. S. Geological Survey, the highest authority on Appalachian geology, calculates that the earth's crust between Cincinnati and the Atlantic coast was formerly over 200 miles longer than it is now; that is to say, these two points have been brought that much nearer to each other as the result of the horizontal pressures, towards the west, of the earth's crust near the Atlantic coast.

Most earthquake zones are the scenes of compression and mountain building, though the movement is invisibly slow. The coals have progressed farthest on the road to anthracite and graphite in those regions where the greatest actual horizontal compression of the strata including the peat beds has taken place.

The temperatures developed in the process are those due to depth of burial of the deposit—say 1° F. to each eighty feet down-

ward through depths averaging about two thousand feet, plus the heat generated by friction due to the compression, through millions of years, of the rocks as just described, and finally, the heat caused by chemical action in the buried strata. Altogether, however, the temperatures in the coal beds were probably less than 300° F. in most coal regions. Comparative lowness of temperature is, however, compensated by great length of geologic time, time and temperature being, in fact, partially interchangeable in the geological transformation of coals.

To illustrate: In portions of the state of Washington relatively young coals, of an age probably not less than nine million years old, have through drastic compression—forced marches, so to speak—been brought to the same stage of evolution as the coals laid down perhaps a hundred million years earlier in the Appalachian and mid-continent states. Some of these Washington coals and some in Colorado that may be twelve million years old are changed even to anthracite. In Rhode Island the peats which grew at the same time as those in Pennsylvania or Arkansas have been changed nearly to graphite. They can be burned if one tries hard enough, but they are at present much more useful as facings in molds for casting iron than for fuel. The well-known metamorphism of coal by contact with hot or even melted rocks that have risen from great depth in the earth's crust is essentially local and relatively unimportant.

The amounts of carbon, hydrogen, oxygen and nitrogen in any coal as a whole can, of course, be determined by the chemist, but very little is known as to the multitude of chemical combinations of these elements which must exist in it. They change more or less from rank to rank of the coal. In burning coal, nearly all the heat is furnished by the carbon and hydrogen, the oxygen being about as objectionable as water or ash. Fortunately, the oxygen, which composes nearly half of the solid plant matter at the start, gradually is driven off so that the coal improves steadily until it passes above the semi-bituminous stage when, on account of rapid losses of the hydrogen, which per unit produces three times the heat of carbon, the heating value of the coal drops off notably in the anthracites. So, in the midst of the dirt, soot and less healthful environment in which we are forced to live in response to anthracite strikes and the exhortations of government bureaus and engineers to burn soft coals because they are cheaper and plentiful, the solitary ray of comfort that comes to us is the greater heat given by these coals. Washington was once the city beautiful and white.

Coal is still the world's greatest source of industrial power and it will remain so for a long time, for the coal reserves of the world probably exceed 10,000 billion tons. Our portion, over 3,500 billion tons, of these vast supplies, should last us many centuries in spite of increasing population and expanding industries, though our coal exportation probably will not grow correspondingly. The actually depressing feature is that we are rapidly mining our limited reserves of best and most valuable coals first. It will be no long period before our so-called smokeless or Navy coals will be largely consumed, and we shall be using inferior and generally dirtier coals mined from thinner beds, at greater depth and at greater cost. Our anthracite reserves, the years of which are said to be numbered, are already put upon a conservation basis of what our friends the economists call "reservation for the highest purposes" which in this case seems to mean the poorest coal for the greatest number. The small consumer, who is mostly the householder, does not buy his coal on specifications.

Coal fields occur in every continent and in nearly every country of the earth. Coal beds, thick and pure, are found above the old soils on which the plants grew in the Antarctic continent as far as 80° S., and in most of the lands surrounding the North Pole. Thus, they occur within 9° of the North Pole in Spitzbergen and Franz Joseph Land, and are present also in the northernmost islands of British America and in Nova Zembla.

Curiously enough, in any geological period the coals laid down in the Arctic regions were in general formed from the same sorts of vegetation, and to a great extent from even the same genera and species, including trees of large size, as were the coals formed during the same periods, in the swamps of West Virginia, Colorado or Washington. There is food for thought in the extraordinary north-south distribution of some of our ancient coal-forming trees, shrubs and ferns—the occurrence, for instance, of the remains of fossil forests beneath the ice of Antarctica, and about 15° beyond the Arctic Circle in Franz Joseph Land.

FOODS DISCOVERED WITH AMERICA

By Dr. WILLIAM E. SAFFORD

I WONDER how many of those who are listening to-night realize that the plants of our gardens, the cereals of our fields and the fruits of our orchards were developed from wild plants, many of them by primitive tribes, before the dawn of civilization; among

the American plants maize, from some native grass; potatoes, from a wild nightshade of the Peruvian Andes; sweet potatoes, from a fleshy-rooted morning-glory; beans and lima beans from wild twining plants growing in thickets; pumpkins and squashes from trailing gourds, probably bitter and uninviting in their wild state; tomatoes and red peppers, from wild plants, with inferior fruits, growing on hillsides and plains of tropical America. From classic writings of the Greeks and Romans we learn something about the principal foods eaten at their feasts and of the plants cultivated in the gardens and groves of the Mediterranean region. From early Sanscrit, Chinese and Arabic writings we derive a knowledge of the principal foods of Asia. From these and from ancient herbals we can form a complete list of the food plants used before the discovery of America, in the Old World the origin of many of which is lost in antiquity.

To-night I shall speak of the food plants of ancient America, developed from wild species by the Indians, all of them strange to the discoverers and explorers of the New World. It was in quest of food products that Columbus set out upon his memorable voyage. He may well be called the pioneer of agricultural explorers. He had no idea of discovering a new world. Convinced that the earth was round, his object was to find a short, westerly route to the lands described by Marco Polo and other early writers, especially to the Spice Islands, from which he hoped to bring back a cargo worth its weight in gold. Before embarking he provided himself with samples of cinnamon, cloves, peppers, nutmeg, ginger and the fragrant aloes wood, which is burned as a perfume in temples of the Orient. After reaching the West Indies he exhibited these samples wherever he landed, indicating by signs that such substances were the object of his search. When the natives appeared to recognize some of them, he imagined that he had indeed reached his destination and so reported to his patron, the King of Spain.

In the narrative of his voyages notes were made of the various foods encountered, and this information was amplified by Las Casas and later explorers, so that the identity of the plants mentioned by him became well established.

The first foods encountered by Columbus were two thick roots which he called *niames*, or *yams*, a name applied to somewhat similar roots growing in Africa. Later entries in his journal describing a kind of bread called *casabi*, made from the larger of these roots, identify it at once with the manioc, or mandioca, from which the tapioca of commerce is derived. The second root, called *ahe* by the natives, having a delicious taste of chestnuts, proved to be the sweet potato.

It is not possible, to-night, to enumerate all the food plants encountered by the early explorers of the West Indies. Most of them, it is safe to say, had been brought from South America by the aboriginal inhabitants of those islands. Among them were Indian corn, or *maize;* beans, quite distinct from the European faba; peanuts; red peppers; Carib cabbages, resembling the taro of Polynesia; among the fruits, guavas; various species of custard apples, including sour sop, sweet sop and bullock's heart, allied to our so-called paw-paw; the true paw-paw, or papaya, whose soft, upright stem was used by the Carib children as a target for their arrows; grenadilla, or passion-flower fruit; and, best of all, the delicious pineapple, which Columbus encountered on his second voyage. Such fruits as oranges, lemons, apples, pears, peaches and bananas were lacking. Certain fruits resembled plums, but they were quite different from true plums and were borne on plants botanically allied to the mango of the East Indies.

It may be well also to mention tobacco and cotton, as found in these islands, the latter belonging to the species from which our best long staple cotton has been developed, quite distinct from the Asiatic cottons from which the calico of Calcutta and the Chinese nankeen were woven.

Turning to Mexico, I shall have no time this evening to tell of the wonderful gardens of the Aztecs, described by Cortez in a letter to his king. It will be sufficient to say that maize, or corn, red peppers and beans were the chief food staples of the Mexicans, while their greatest delicacy, chocolate, was made from the seeds of cacao and flavored by vanilla, extracted from the fruit of an orchid which climbed the forest trees of Vera Cruz; and by a spicy flower called *ear flower* from the resemblance of three of its petals to the human ear.

From the agave, or century plant, the Indians of Mexico and of our own southwest derived sugar, vinegar and a fermented drink; and from prickly pears and other cactus plants, sweet syrups and various kinds of marmalades. The Mexicans also cultivated sweet potatoes and tomatoes. One of their best fruits was the avocado, recently introduced into the United States. Their principal tobacco was a yellow-flowered species, quite distinct from that of the West Indies, but identical with the tobacco cultivated by the North American Indians east of the Mississippi River. One other aromatic product of the West Indies and tropical Mexico should also be mentioned, the allspice, which grows on a tree closely allied to that which yields the fragrant oil of bay rum.

In South America, the Portuguese in Brazil and the Spaniards in Peru and Chile found in cultivation nearly all the plants I have

mentioned, the principal food staple in Brazil being the manioc, or cassava plant, and in Peru maize or Indian corn. Each of these countries had species of cotton allied to but distinct from those of the Antilles and Mexico.

In Brazil was also found the arrowroot and, growing in the terraced mountains of the west coast and on the great plateau of Bolivia, the so-called Irish potato, perhaps our most important heritage from ancient America. In the mountains of Peru were also found the cherimoya, most delicious of all the custard apples, and the aracacha, an aromatic celery-like plant which would undoubtedly have been more widely cultivated in the New World if we had not the introduced celery itself. In Paraguay the most important plant was a species of Ilex, or holly, from the leaves of which a stimulating tea was prepared, now commercially known as *yerba mate*. In Florida a similar tea, called cassine, was prepared from a closely allied species, which took the place of China tea, when that was lacking, and was used in the celebrated Black Drink of the Indians of southeastern United States.

In North America the early colonists found the Indians of the Atlantic coast, from the Carolinas to Canada, cultivating, in addition to corn, beans, squashes, pumpkins and tobacco, the sunflower for the sake of its oil-yielding seeds and the closely allied Jerusalem artichoke for its fleshy tubers.

In addition to the cultivated crops there were other plants growing spontaneously in the marshes and forests; some of them, like the yellow-flowered lotus, arrowleaf and Virginia arum, botanically allied to important species now cultivated in the water gardens of Asia. To these must be added the wild rice, from which the Menominee Indians take their name, and the Indian potato, or marsh potato, a tuber-bearing plant called *openauk* by the Algonquin Indians, from which certain tribal clans and villages were named.[1] It would have been hard for the early colonists, if they had had only cultivated crops to depend upon. When there was dearth of food in Virginia and New England, they were driven to eat the wild products of the swamps and woods. Of the Virginia arum, called "tuckahoe" by the Indians, Captain John Smith declared that raw it was no better than poison, and that it "tormenteth the throat," a remark which might have been made of the allied taro of Polynesia, or the Carib cabbage of the West Indies, which sting the mouth with microscopic needles embedded in their tissue,

[1] For illustrations of this plant (*Glycine apios*) and its strings of roots see "The potato of romance and of reality," in *Journal of Heredity*, Vol. 16, plates 4 and 5, April, 1925.

like the Jack-in-the-pulpit or Indian turnip of our woods; but which, when properly sliced, dried and cooked, was an important food staple of the Indians.

The most important of all the forest trees was the maple, from the sap of which the Indians made their sugar. Among the nuts the most important were the pecan and the hickory nut, from the latter of which a delicious creamy emulsion was made by pounding the nuts with water, in a mortar, straining out the shells and pouring off the surface water after the rich cream had settled. It was this substance, called pawhiccora, which gave the hickory nut its name. From hickory nuts and butter nuts delicious oils were made. Other products of the forest, including walnuts, hazel nuts, chestnuts and beech nuts, resembled Old World species, but differed from them specifically. The same is true of some of the berries, including strawberries and blueberries, from which we have developed such fine cultivated forms; also the wild grapes, from which have been derived our Concord, Catawba, Delaware and other hybrids. Another fruit quite different from anything in Europe, but with relatives in Asia, was the persimmon, which the Indians preserved by drying, and from which they made a fermented drink.

Jacques Cartier, during his exploration in Canada, in 1535, came upon Indians on the shores of Georgian Bay who were picking blueberries to dry for the winter. Other Indians in this region travelled about bartering sunflower-seed oil and tobacco for other commodities, and one of the early French missionaries describes how, forced by starvation, he went to the woods to dig Indian potatoes or groundnuts, which he called chapelets, or *rosary roots,* from their bead-like arrangement in strings.

What I have said of the resemblance of certain plants to Old World forms, from which they differ specifically, applies also to many animal foods of America. Thus the delicious Virginia oyster, upon which the Virginia colonists fed at certain seasons, is quite distinct from the European species. The lobster of the Atlantic coast, the spiny lobster, or crayfish, of the southern waters, and the more northerly scallops and clams, are all quite distinct from corresponding European species, and the delicious shad and pompanos of the western Atlantic are essentially American.

In concluding my talk I would like to present an American menu, somewhat similar to one served at a dinner given in honor of a visiting European botanist, composed entirely of dishes made up of foods discovered with America:

Cocktail of Virginia oyster, with sauce of tomato and red pepper
Chowder of little-neck clams, with tomatoes and green corn, with opossum fat substituted for pork
or
Terrapin stew, made with turtle eggs
Barbecued shad à la Indienne, with white potatoes; and tamales à la Mexicaine
Bell peppers or tomatoes, stuffed with wild rice
Turkey, stuffed with native chestnuts or oysters; cranberry sauce, sweet potatoes, string beans, succotash of lima beans and green corn, stewed tomatoes, Jerusalem artichoke, corn-pone or hoe-cake, guava jelly
Salted peanuts
Sherbet, passion-flower fruit à la Martinique
or
Sour-sop à la Havanne
or
Cherimoya à la Peruvienne

For the game course:
Quail, rice birds or canvasback ducks, blackberry or grape jelly
Salad of avocado (or alligator pear), with dressing of sunflower or hickory nut oil and maple vinegar, and cayenne pepper and salt
Pineapple tapioca
Pumpkin pudding
Stewed blueberries
Strawberries
Grapes, wild plums
Pecans, Brazil nuts, water chinquapins (or lotus fruit) hickory nuts, pine nuts, hazel nuts, popcorn
Chocolate—yerba maté—cassine tea
Cigars and cigarettes

Would any one go away from this dinner complaining of the lack of milk, eggs or wheat flour of the Old World?

CARLSBAD CAVERN

By Dr. WILLIS T. LEE
U. S. GEOLOGICAL SURVEY

After listening in with you on numerous occasions, it is a pleasure to stand at the other end of the air and bring to you, through the air, the news from an underground realm. This is a special pleasure because, as a former flyer, I abandoned the air to go underground and am now back on the top of terra firma—safe.

Carlsbad Cavern has nothing to do with Carlsbad in central Europe. It is situated in southeastern New Mexico in the valley of the Pecos River—not Arizona as announced in the newspapers.

This cavern has been known locally for a long time. But not until the news of its unusual character was received by the readers of the *National Geographic Magazine*, about a year ago, did the world at large know anything about it.

The discovery of the astonishing nature of this cavern was the result of examinations made of proposed reservoirs on Pecos River. The rocks which cause the reservoirs to leak contain the great cavern.

Following the first publication, the National Geographic Society sent an expedition to explore the unknown parts of the cavern. For nearly six months we were engaged in this work, and many interesting discoveries were made.

Carlsbad Cavern is the work of water. Like many another well-known cave, it was made by the solution of parts of the rocks. It differs from others in that the limestone rocks here contain beds of gypsum and rock salt. Through long ages the underground water dissolved and carried away soluble material, leaving a great cavity deep down under the highlands.

In the course of time this process was reversed and the water, carrying carbonate of lime in solution, deposited this material within the cavern in the form known as cave marble.

The solution formed subterranean chambers of astonishing size. Deposition decorated these chambers with adornments of surprising variety and beauty. Also deposition cemented together such loose fragments as may have existed and thus made improbable such tragedies as that of Sand Cave in Kentucky.

What Niagara is to waterfalls, Carlsbad is to caverns. It is king of its kind.

The National Geographic Society's camp was established at the mouth of the cavern, twenty-six miles from Carlsbad. This is a desert region, and the nearest spring is nearly a mile away. Water was carried by burro, and fire wood was "rustled" from the mountain side.

There was no refrigerator in camp and there were no shade trees. Sometimes the temperature reached 110° in the shade—and no shade could be found.

But the cavern is always cool. There we found a uniform temperature of 56° F. A small opening near the elevator shaft served in place of a refrigerator. Provisions lowered into this opening were kept cool and fresh.

Long ages ago bats learned that the cavern was a nice cool place in which to spend the hot days. Great numbers of them may be found in the cavern any day. But just after sundown they come out to spend the night on the wing, feeding on night-flying insects. Before dawn they are back again, each tucked snugly away in his chosen crevice or hanging head downward from the ceiling.

The bats did not approve of the National Geographic Society's activity. The lights disturbed their slumbers. As we passed through their chamber they circled about and scolded. Not knowing bat language, I can not translate their remarks, but I am sure they were not complimentary.

We never remained in the cavern over night. The cave air is damp. A slight extra effort started the perspiration, and relaxation was followed by chills. Clothing left below from day to day became damp and mouldy.

Our work in the cavern was done by the light of gasoline lanterns. Most of the time was spent in chambers nearly eight hundred feet beneath the surface, and a mile or more from the entrance.

The absolute darkness and the unbroken silence of these subterranean places affected the workers in different ways. Some feared the dark and frankly confessed it; others feared and were ashamed of the weakness. Some were attracted by the mysteries of the unknown; others clung tenaciously to the beaten path.

All who worked regularly in the cavern were under mental strain. Their nerves were "jumpy." There was much discussion about the possible collapse of the roof. The possibility of disaster affected the night dreams as well as the day dreams.

One night in the "wee small hours" a terrific commotion was heard and the men rushed out of the bunk house, exclaiming excitedly that the cave had collapsed. No evidence of the disaster was found. But a fresh disturbance back of the bunk house directed attention to old Pete, the burro that carried wood and water to camp. His feet were tangled in the wires of an old bed spring into which he had ventured too far in search of tempting bits of cloth, of which he is very fond. In his efforts to free himself from the wire entanglements, he had stumbled down the hillside against the bunk house, bringing with him several loose boulders.

The first work in the cavern was done on the trail. Rough places were smoothed out and such improvements made that we reached our work in little more than an hour's time, whereas it had previously taken more than two hours to go in and two to come out.

The chambers previously explored were used as points of departure for new discoveries. From them we pushed our way into the unknown parts.

Tom Sawyer was emulated in the use of kite strings. We used white twine, which was left as permanent markers. In time we had a system of avenues, with white twine markers leading to the exit.

Allow me now to take you on a personally conducted tour through this new wonderland. It must be a flying trip, for it would take days to examine all the strange features.

The cavern is approached from Carlsbad over a plain and up a mountain side to an opening where the roof collapsed. Near this opening a shaft has been dug and fitted with a windlass and wire rope having an iron bucket at the end. We climb into this bucket, the floor at the top of the shaft opens, and we descend 170 feet into the Stygian darkness.

After a little time spent in adjusting the lanterns and getting our "cave eyes" we take the trail, picking our way over and among great blocks of rock which fell from the ceiling.

We pass beneath the great opening where the roof fell 250 feet, climbing up and down and over and around blocks of rock in the spacious corridor with ceiling so far above that the lanterns only dimly illuminate it.

Three quarters of a mile from the entrance and more than eight hundred feet under the surface, we reach the roughest place on the trail. Here were found parts of a human skeleton. Some cave man had lost his way and perhaps fell from rock to rock in the darkness to the shelf where his earthly career was ended.

The spectacular part of the cavern begins just beyond this difficult part of the trail.

The first chamber to be entered is Shinav's Wigwam. It is nearly circular in outline, two hundred feet across, seventy-five feet high and wonderfully adorned. At the entrance to this glorified wigwam of the Navajo's wolf god hangs a large stalactite of gnarled appearance, which resembles a cave man's war club.

The wigwam is surrounded by alcoves and niches and tributary chambers of marvelous character and amazing adornment. Had the author of "Arabian Nights" seen Carlsbad Cavern, he might have enriched his tale of Aladdin and his lamp with facts stranger than the fictions used.

One of the most beautiful of these tributary chambers was discovered when one of the explorers crept through a small hole in the wall of the wigwam. The partition here is thin and a surprisingly spectacular view never before seen by human eye opened at once to his astonished gaze.

This new chamber was named Avanyu's Retreat for the wise serpent of Indian mythology, who is said to have lived in the waters of the underworld and who insisted on attending the councils of the gods.

An effort is being made to use in the cavern place names taken from Indian mythology.

We must not linger long in the wigwam, for the most spectacular part of the cavern lies beyond. To reach it we climb over a pile of rocks 183 feet high on the floor of an enormous vault whose ceiling rises 350 feet above the floor. The inner slope of this hill leads down through a decorated archway into the Big Room—a great

cavity half a mile long and surrounded with tributary chambers and corridors, alcoves and niches.

These tributary avenues were searched in the hope of finding an exit through which an easy entrance to the cavern might be constructed. The search led to many new discoveries—too many to be even mentioned to-night.

We succeeded in finding no outlet, but the survey proves that the end of the Big Room is only twelve hundred feet from the foot of the mountain. A tunnel driven into the mountain will lead directly to the spectacular part of the cavern. It is expected that this tunnel will soon be dug.

Some of the most interesting discoveries were made in the basement of the cavern.

A series of chambers was found ninety feet below the floor of the Big Room. The guide was lowered first on a rope through a hole in the floor. He had an unhappy time. In the uncertain light of his kerosene torch, things looked strange and unreal. All went well until he reached water in the fountain at the bottom of the hole. To his perturbed mind this seemed like an ocean. His frantic signals to be raised were misunderstood and he was dropped unceremoniously into the water. With light gone, he passed an unhappy moment in the darkness before he discovered that he could touch bottom.

Later a wire ladder ninety feet long was built and lowered into the hole. The lower seventy-five feet of the ladder swung clear of the wall. A wire ladder has an erratic disposition and an obstinate nature. Those who first descended swayed and spun about in the darkness. Those who possessed weak nerves had a sorry time.

The newly discovered chambers are extensive and wonderfully decorated. It is quite impossible to describe them. The only way that a realization of their marvelous nature can be secured is to see them.

Carlsbad Cavern is only one of many caverns in the Guadalupe Mountains. But this is another story!

JOHN BARTRAM, BOTANIST

By Dr. WILLIAM SHAINLINE MIDDLETON

THE UNIVERSITY OF WISCONSIN

THE lower reaches of the Schuylkill, flanked by manufacturing plants and refineries, present a strange contrast to the "fine prospect . . . and rich meadows," which James Mease described in 1810. The present-day student of nature, unfamiliar with the historic past of this region, will find little incentive to a close acquaintanceship. Indeed, the murky skies and even murkier waters seem most forbidding to such studies and even to the opportunity for them. Yet on the right bank of the Schuylkill, near old Gray's Ferry in Kingsessing Township, John Bartram established the first botanical garden of consequence in America in 1730. The botanical gardens of the Rosicrucians and of Dr. Christopher Witt antedated the Bartram Garden; but in the case of the former only medicinal herbs were cultivated for the use of the brotherhood, whereas the latter garden had a rather limited influence in the advancement of botanical knowledge. So that in effect the current statement of the priority of the Bartram Garden is essentially true. The present state of the garden suggests its former glory as little as does the shell the living "Acada Septendecim" which Bartram so faithfully portrayed; yet here he labored with loving hands, gathering the native flora from the Great Lakes to the Gulf and from the Ohio to the sea; also nurturing the seeds and plants sent to him from foreign lands. From the Colonial period on, this garden spot played an important rôle in the life of Philadelphia. Here Washington, Franklin, Hamilton and Jefferson found peaceful repose from their arduous tasks in the capital of the new republic. Here Alexander Wilson, a drifting youth from Paisley, found an impetus to new endeavor and from the denizens of its leafy bowers drew the subjects which formed the first standard treatise on American ornithology. For him as for other frequenters of this charmed spot romance was abroad and he married a niece of his friend, William Bartram. Here students of nature and of art have through the generations found ample materials for instruction and reflection. And here Weir Mitchell, in characteristic strain, brought his hero, Hugh Wynne, for refuge and refreshment on his flight from Philadelphia. John Bartram and his garden interest us especially by reason of their botanical contributions.

Botany is "the eldest daughter of medicine." As John Bartram pointed out, primitive peoples in all ages have sought relief

from their physical ills by natural or the most available means. Herbs and plants of reputed medicinal value came into general or local use according to the individual and collective experience with respect to their efficacy. With the ascendency of therapeutic nihilism and, more rationally, under the scientific scrutiny of pharmacologic study, many of the familiar vegetable preparations of our forefathers have lost favor. Unquestionably much of the poetry of medicine departed with the passing from daily usage of hepatica, quebracho, euphorbia, convallaria, arum and a legion of other old favorites. No more does the physician lean for uncertain support on pleurisy root, snake root, wahoo, spikenard, black cohosh, burdock, meadow rue and juniper berries. Yet what physician is ready to discontinue the use of the deadly nightshade, foxglove, poppy and coca? The indebtedness of medicine to the vegetable kingdom is enlarged when the sources of camphor, nux vomica, cinchona, ergot, ipecac, kino, physostigma, chaulmoogra, glucose, saccharose and the salicylates are considered. If to these be added practically all the anthelmintics, carminatives, emollients, bitters, local counter-irritants, irritating laxatives and a large group of indirect derivatives of the vegetable kingdom such as alcohol, ether, coal-tar products and their kind, the overwhelming dependence of medicine on her neglected eldest daughter is in a greater measure appreciated.

To comprehend the low estate to which botany has fallen in the estimation of the medical world it is essential that its past position of honor be appreciated. The yoke of mysticism and spiritualism in the practice of medicine was only removed by the recognition of natural causes for disease and its expressions. The relief of disease and its manifestations was for centuries primarily a function of the priesthood who judiciously supported nature by the use of medicinal herbs and attributed both cures and failures to divine intervention. With the gradual divorce of medicine from the clergy it was natural that physicians should seek to fortify themselves by a superior knowledge of the medicinal properties of available herbs. In turn medicine was responsible for the early growth of botany as a science. Theophrastus of Eresus, in Lesbos (B. C. 372–285), was the first physician-botanist of note. He collected or described by personal observation and inquiry some five hundred plants. Dioscorides, a physician to Nero, was likewise a distinguished botanist. However, it was not until the sixteenth century A. D. that botany saw its greatest growth as an applied as well as an abstract science. In this period Valerius Cordus (1515–1544) and Andrea Cesalpino (1524–1603) made fundamental contributions to the systematic study of plant life. Cordus, in addition, compiled the first dispensatory which was adopted by the

Senate of Nuremburg in 1535 as the standard for their apothecaries and probably first printed in 1546, at the expense of the Senate. Cesalpino effected an artificial classification of plants according to their organs of reproduction, therein antedating Linnaeus. Pioneer spirits explored the Orient and the Mediterranean lands for new flora. Gonzalvo Hernandez Oviedo y Valdez (1478–1547), viceroy of Mexico, and Nicholas Monardes, of Seville, furnished the earliest accounts of the medicinal plants of the New World. To the latter belongs the priority for the description of coca (1569). Travellers in all new countries were awake to the importance of the discovery of plants with medicinal properties. Thus in the succeeding century cinchona and ipecac were introduced into Europe. The Countess of Chinchon suffered from malarial fever in Lima, Peru (1630), and her prompt response to the native bark led the Jesuit priests to take it to Europe in 1632. Professional jealousy and religious differences retarded the spread of this specific for some years. Ipecac was brought from Brazil to Europe by the Portuguese friars early in the seventeenth century. Indeed, wherever the flora of a new country was investigated by these pioneers, the probable medicinal value was uppermost in their minds.

To this group of worthy benefactors of mankind belonged John Bartram. Hector St. John de Crevecoeur, a romancer of the Colonial period in Philadelphia, has attached the following pretty circumstance to the entrance of that matter-of-fact Quaker into botanical study:

> One day I was very busy in holding my plough (for thou seest that I am but a ploughman), and being weary I ran under a tree to repose myself. I cast my eyes on a daisy; I plucked it mechanically and viewed it with more curiosity than common country farmers are wont to do, and observed therein very many distinct parts, some perpendicular, some horizontal. "What a shame," said my mind, "that thee shouldst have employed thy mind so many years in tilling the earth and destroying so many flowers and plants without being acquainted with their structures and their uses." I thought about it continually, at supper, in bed and wherever I went.

An inquiry into the validity of this legend reveals that John Bartram had written to Alexander Catcot, in 1742, of his inclination to botany and natural history from the age of twelve years. His son, William, remarked that "he had a very early inclination to the study of physic and surgery. He even acquired so much knowledge in the practice of the latter science, as to be very useful: and, in many instances, he gave great relief to his poor neighbors, who were unable to apply for medicines and assistance to the physicians of the city. It is extremely probable that, as most of his medicines were derived from the vegetable kingdom, this circum-

stance might point out to him the necessity of, and excite a desire for, the study of botany."

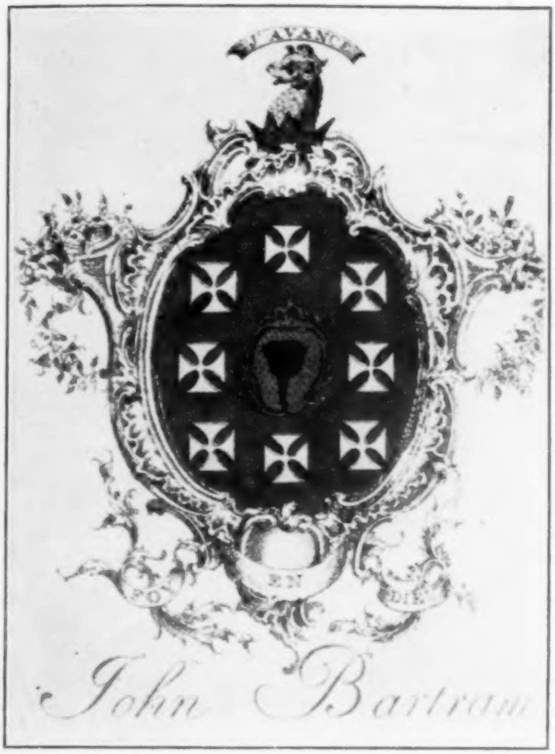
The evidence is clear, therefore, that John Bartram entered the serious study of botany from his primary interest in physic. His attitude is best translated in Emerson's words:

> If I knew
> Only the herbs and simples of the wood,
> Rue, cinquefoil, gill, vervain and agrimony,
> Blue-vetch and trillium, hawkseed, sassafras,
> Milkweeds and murky brakes, quaint pipes and sundew,
> And rare and virtuous roots, which in these woods
> Draw untold juices from the common earth,
> Untold, unknown, and I could surely spell
> Their fragrance, and their chemistry apply
> By sweet affinities to human flesh.
> Driving the foe and establishing the friends,—
> O, that were much, and I could be a part
> Of the round day, related to the sun
> And planted world, and full executor
> Of their imperfect functions.

John Bartram never completed the study of medicine as Haller and others have erroneously stated.

Having resolved to pursue the study of botany, Bartram faced almost insuperable obstacles in the accomplishment of his end. His level-headed wife attempted to dissuade him on the grounds of the detracting influence of such an avocation from the work of the farm. At first he was inclined to heed her advice, but finally the lure of the unknown overcame the force of her objections and Bartram sought the counsel of a bookseller in Philadelphia. The common botanical texts were in Latin; so he procured a Latin grammar together with a text on botany. Obviously, a native-born American of Quaker farmer parents was afforded very meager educational advantages in the Colonial period. However, with the assistance of a neighboring schoolmaster and by dint of close application he obtained a working knowledge of the classical language and of the rudiments of botany. His fundamental deficiencies were never entirely effaced; but his energy and assiduity in collecting and describing the wonders of the plant life of America led Linnaeus to term him "the greatest natural botanist of the age."

The scope of Bartram's influence and the extent of his observations were greatly enhanced by the fortunate enlistment of the interest of Peter Collinson, of London, through the mutual services of James Logan and Joseph Breintnall. Collinson, a wool-draper by occupation, was one of the most distinguished patrons of natural science in the English-speaking world of the eighteenth century.



THE BARTRAM COAT OF ARMS

Through his wide acquaintanceship, scientific and financial recognition came to the obscure Bartram toiling in the wilds of a new continent. The fascinating correspondence between the two kindred spirits was preserved to posterity by the unusual custom of Bartram in retaining a rough copy of all his letters together with all received messages. To him this contact with Collinson and other students of botany in this country and abroad must have been the very breath of life, and we can picture him reading and re-reading the letters of Linnaeus, Gronovius, Catesby, Sloane, Fothergill, Colden, Garden and Franklin by the uncertain candle light after his labors of the day were ended. Many of these original letters are preserved by the Historical Society of Pennsylvania, but unfortunately the Linnaean manuscripts are missing. To William Darlington due credit is given for the difficult labor of love in the transcription of these letters, whereby they have been rendered more generally useful.

The interesting correspondence between Collinson and Bartram continued, without visits between the principals, for some thirty-

BARTRAM HOMESTEAD
Eastern (Front) Exposure

five years. Collinson on his part professed a most receptive attitude. "My inclination and fondness to natural productions of all kinds is agreeable to the old proverb: Like the parson's barn,—refuses nothing." Every letter from England brought renewed requests for seeds or plants or expressions of gratitude for past favors. For example, on January 20, 1734, Peter Collinson wrote:

> Please to remember those Solomon's Seals, that escaped thee last year. The great and small Hellebore are great rarities here, so pray send a root or two of each next year. Please to remember all your sorts of lilies; and your spotted Martagons will be acceptable.
>
> The Devil's Bit, or Blazing Star, pray add a root or two, and any of the Lady's Slippers.

In this particular letter are included directions for the packing of botanical materials, for in the long transit of two to three months losses through the inroads of rodents and other vermin were most disheartening. "A great many may be put in a box 20 inches or 2 feet square, and 15 or 16 inches high;—and a foot in earth. This may be put under the captain's bed, or set in the cabin, if it is sent in October or November. Nail a few small narrow laths across it, to keep the cats from scratching it." Another passage suggests the use of tobacco leaves to protect letters from insects.

Nor were Collinson's requests limited to the vegetable kingdom. At times it was a plea for birds, again for birds' nests. Moths

were sought on another occasion. Turtles were always interesting to this omnivorous student of nature. A characteristic passage reads:

> If any Land or Water Terrapins happen in thy way, save them and send them; but not the great Mud Turtle. I only want his shell; and if Billy would paint his curious figure, it would be better. If any Orchis, Calceolus Maria, Martagons, Lilies, or any other curious plant—think on thy old friend, P. Collinson.

The following attests his diversified interest:

> In the course of thy travels, or in digging the earth, or in thy quarries, possibly some sort of figured stones may be found, mixed or compounded with earth, sand, or stone and chalk. What use the learned make of them is that they are evidences of the Deluge.

In return for Bartram's contributions Collinson at first made numerous gifts of a personal nature. For instance in January, 1735, he wrote:

> I am very sensible of the great pains, and many tiresome steps, to collect so many rare plants scattered at a distance. I shall not forget it; but in some measure to show my gratitude, though not in proportion to thy trouble, I have sent thee a small token: a calico gown for thy wife, and some odd little things that may be of use amongst the children and family.

BARTRAM HOMESTEAD
Eastern (Front) Entrance

ENTRANCE—EAST

John Bartram thus expressed his gratitude for favors received from Peter Collinson, December 10, 1745:

Now, though oracles be ceased, and thee hath not the spirit of divination,—yet, according to our friend, Doctor Witt, we friends that love one another sincerely, may, by an extraordinary spirit of sympathy, not only know each other's desires, but may have a spiritual conversation at great distances one from another. Now, if this be truly so,—if I love thee sincerely—and thy love and friendship be so to me—thee must have a spiritual feeling and sense of what particular sorts of things will give satisfaction; and doth not thy actions make it manifest? For, what I send to thee for, thee hath chosen of just such sorts and colours as I wanted. Nay, as my wife and I are one, so she is initiated into this spiritual union; for thee has sent her a piece of calico so directly to her mind, that she saith that if she had been there herself, she could not have pleased her fancy better.

A most happy acknowledgment from a period when the affairs of men ran less tumultuously than to-day and men found time to voice their sincere appreciation!

However, the tide of correspondence between these two Quaker botanists did not run smoothly at all times. The frugal Collinson at one time thus resented the disposition of certain wearing apparel sent to Bartram:

One thing I forgot to mention before, and what very much surprised me, to find thee, who art a philosopher, prouder than I am. My cap, it is true, had a small hole or two on the border but the lining was new. Instead of giving

it away, I wish thee had sent it me back again. It would have served me two or three years, to have worn in the country, in rainy weather.

Of Collinson's disinterested services to the Pennsylvanian there can be no doubt. He personally enlisted the financial support of several wealthy British commoners and noblemen in Bartram's work. Chief among these were Philip Miller, Lord Petre and the Duke of Richmond. Their first commission consisted in the request for an accurate mapping of the Schuylkill River, a task which Bartram discharged to their complete satisfaction. But their primary interest was in the enrichment of their gardens by the importation of strange plant life from America. By this medium Bartram was responsible for the introduction into England of the bush honeysuckle, fiery lilies, mountain laurel, dog-tooth violet, wild asters, gentian, ginseng, sweet ferns, magnolia, tulip, locust trees, hornbeam, witch-hazel, spruce, hemlock, red and white cedar and sugar maple. This is by no means a complete list nor was the current entirely eastward; for his English friends were at the same time enriching the flora of his garden by their contributions. To him came lilacs, tulips, narcissus, roses, lilies, crocuses, gladioli, iris, snapdragons, cyclamens, poppies and carnations, in addition to many species of fruit and shade trees. The charming introduction of one exotic tree to our shores by Collinson invites preservation:

Don't use the Pomegranate inhospitably, a stranger that has come so far to pay his respects to thee. Don't turn him adrift in the wide world: but plant it against the south side of thy house, nail it close to the wall. Dr. Fothergill says, of all trees this is the most salutiferous to mankind.

Peter Collinson was not unmindful of the demands patronage might impose. Hence: "Friend John, this is only a hint, by the way: Lord Petre is a great admirer of your foreign wild waterfowl. If at any time an opportunity offers, send him some. Thou will lose nothing by it." Peter evidently felt that it behooved him to act as social proctor to the farmer John. For example, after James Logan had ordered Parkinson's Herbal for Bartram, Collinson wrote (April 28, 1736), "It may look grateful, every now and then, to call and inquire after thy good friend Logan's welfare." He furthermore deemed it advisable to urge Bartram to appear in his best clothes in visiting the Virginians. In 1765 Collinson was instrumental in the appointment of his American friend as botanist to the king at the munificent salary of fifty pounds a year. Two years later he wrote to Bartram thus: "I am glad thou hast sent some plants and seeds to our gracious King, as thy annuity is regularly paid. I dare say any of thy Journals would be

SOUTH END OF BARTRAM HOMESTEAD

very acceptable to him; could they be copied fair? Send him every year one; for he must not be cloyed by too much at once. Begin with the first after thou received the salary. This would keep thee in his memory."

Freed in a measure from the duties on his farm by the aforementioned support, at first from private sources in England and later from the king, Bartram extended his field of botanical collection and study to New Jersey, Delaware, the Catskills and Southern New York, Maryland and Virginia and more latterly to

Georgia, Florida and the western portion of the Carolinas. He explored his native state from the Delaware to the Ohio and throughout its breadth. From its mountains went the beautiful rhododendron, "glorious beyond expression" in Collinson's opinion when it blossomed in his garden. Bartram laconically outlined his trip to Virginia as follows:

> I have performed my journey through Maryland and Virginia, as far as Williamsburgh so up James River to the mountains, in many very crooked turnings and windings, in which, according to the nearest computation I can make, betwixt my setting out and returning home, I travelled 1100 miles in five weeks' time; having rested but one day in all that time; and that was at Williamsburgh.

More remarkable, however, was his trip to Florida in his sixty-sixth year to explore and map the St. John's River and to report on the colonization possibilities of the land. The journal of this period is extant but lacks the vital interest of his journal dealing with the earlier trip to the Five Nations in the company of Conrad Weiser, the commissioner from Virginia, who arranged a treaty with these tribes. In the former the impression gathers to the reader that John Bartram was the unwitting tool of devising agents whose sole interest in his observations lay in his approbation of their lands. Indeed Bartram's rather stilted account of the flora and soil forms a small appendix to William Short's descriptive brochure on Florida. For this position Bartram paid dearly in the subsequent location and dismal failure of his favorite son Billy at indigo farming on the St. John's. "Observations on the inhabitants, climate, soil, rivers, productions, animals, and other matters worthy of notice made by Mr. John Bartram, in his travels from Pensilvania to Onondago, Oswego and Lake Ontario in Canada" embody his earlier journal and contain some interesting commentaries on the subjects mentioned. The Indian customs particularly invited his attention and he wisely remarked, "Their morals are little if at all mended by their frequent intercourse with us Christians, tho I am persuaded it is not the fault of our religion but its professors."

His travels, aside from the physical effort entailed, were not unattended by grave bodily risks. On one occasion he recorded the following:

> I sent Gordon a fine parcel of Holly berries, the getting of which had like to broke my bones. I was on the top of the tree, when the top that I had hold of and the branch I stood on, broke—and I fell to the ground. My little son, Benjamin, was not able to help me up; my pain was grievous; afterwards very sick; then in a wet sweat, in a dark thicket, no house near, and a very cold sharp wind, and above twenty miles to ride home, thee may judge what a poor circumstance I was in; and my arm is yet so weak that sometimes I can

THE STONE DETAIL OF THE WINDOW CASEMENT AND THE DISTICH

hardly pull off my clothes. [But mark the indomitable courage!] Yet I have a great mind to go next fall to Pittsburgh, in hopes to find some curious plants there.

Fever, jaundice and dysentery were his lot on his Florida expedition. Venomous reptiles and not less venomous savages beset his innocent path. One encounter with an Indian was especially disturbing. He wrote: "Many years past, in our most peaceable times, far beyond our mountains, as I was walking in a path with an Indian guide, hired for two dollars, an Indian man met me and pulled off my hat in a great passion, and chawed it all around—I suppose to show me that they would eat me if I came in that country again." However, Bartram's personal reaction to such hostile manifestations was translated in these words, "I hope to set out to search myself, if the barbarous Indians don't murder me (and if I die a martyr to Botany, God's will be done;—His will be done in all things)."

It must not be inferred from this statement that John Bartram with his Quaker upbringing and profession of faith was a supine pacifist. Roundly scoring his friend Peter Collinson, who had philosophically discoursed upon the subject of Indian relations in the *Gentleman's Magazine*, Bartram wrote:

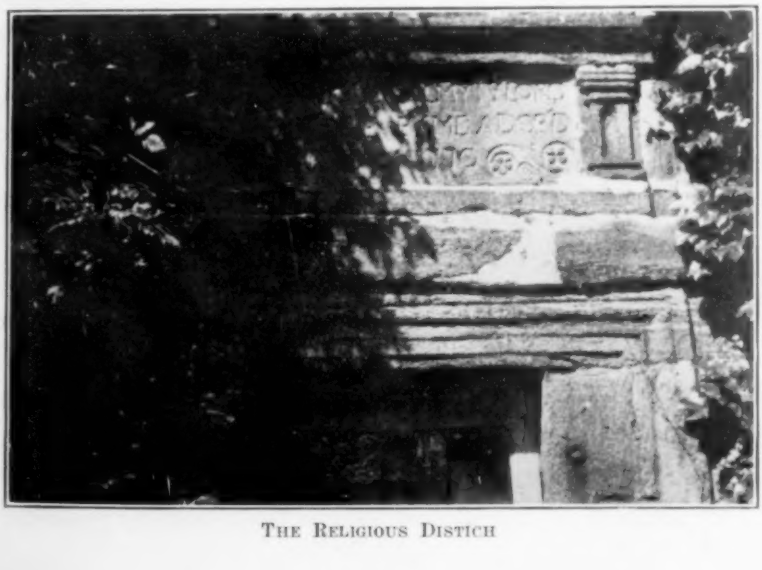
> The most probable and only method to establish a lasting peace with the barbarous Indians is to bang them soundly, and to make them sensible that we are men whom they for many years despised as women. Until then, it is only throwing away men, blood and treasure, to make peace with them. Perhaps now, and only now, is the critical time offered to Britain to secure not only her old possessions, but her so much boasted new acquisition, by sending us sufficient supplies to repel effectually those barbarous savages.

On another occasion he expressed the following sentiment to Benjamin Franklin:

> Thy poor, yet honest Bartram is daily in mourning for the calamities of our province. Vast sums spent, and nothing done to the advantage of the King or country. How should I leap for joy, to see or hear that the British officers would prove by the actions, the zeal and duty to their prince and nation, they so much pretend in words.

John Bartram entertained the current distrust of the French and to them attributed the hostility of the Indians. "O Pennsylvania! thou that was the most flourishing and peaceable province in North America, art now scourged by the most barbarous creatures in the universe. All ages, sexes and stations have no mercy extended," he lamented.

Bartram and Collinson on occasions engaged in amusing raillery at expense of one another. A strong partisan of William Pitt,



THE RELIGIOUS DISTICH

WATER TROUGH

Bartram was the recipient of this thrust from his friend Collinson (1763). "Glorious Pitt so presides in my dear John's mind, he is insensible to complaints, except on the sorry peace that hath given so great an empire to Britain!" To which Bartram retorted, "But the Indians instigated by the French, will not let us look at so much as a plant, or tree, in this great British empire." Peter did not relent. "What a glorious scene is opened in that rich country about Pensacola—if that despised country is worthy thy visitation. But because Pitt did not get it, thou canst not venture there on any pretence! All beyond the Carolinas is forbidden ground. They are none of thy darling Pitt's acquisition."

The advantage was not always to the Englishman. On one occasion he saw fit to chide Bartram for his extravagance in purchasing botanical works, quoting from a biblical source Solomon's admonition that "in the reading of books there is no end." Whereupon John replied, "I take thy advice about books very kindly,—although I love reading such dearly: and I believe, if Solomon had loved women less, and books more, he would have been a wiser and happier man than he was."

Throughout the interchange of correspondence and botanical specimens between Bartram on one hand and his British and Continental friends on the other, there was the constant inquiry into the medicinal value of the different plants. At various times Collinson inquired for "the root of the Aristolochia, which is of such sovereign remedy for sore breasts," "a root of the grassy leaves, that bear pretty little blue flowers,—that's good against obstruc-

tions of the bowels" and the papaw reputed to possess remarkable medicinal virtues. As has been previously noted John Bartram was responsible for the introduction of ginseng into England, and the shrewd Collinson, realizing the economic possibilities of exporting the same to the Orient, wrote:

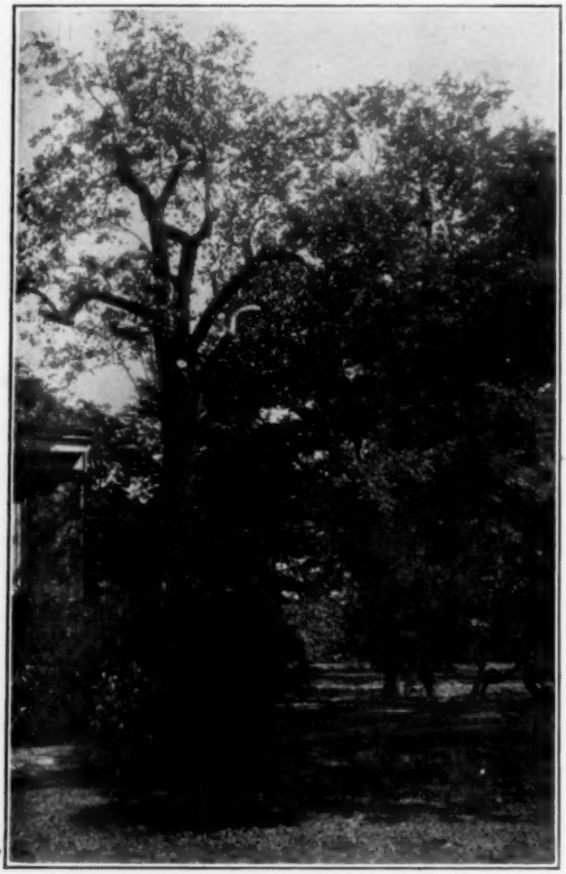
> I sent some Ginseng roots to China. If they sell well a good, profitable trade may be carried on. In the meantime, sow the seed, and raise a stock to furnish my friend, when he returns. I intend the benefit for thyself. Keep that a secret, and raise what thee canst for I have an opinion it will turn to account if my friend manages it rightly.

If the authority of Wood and Bache be admitted, the earliest shipments of the roots from this country to Canton were worth their weight in gold. The Chinese have for centuries credited ginseng with unusual virtue in the control of impotency; and it is to be hoped that Bartram shared in the profits of the exploitation of this root, even though no therapeutic properties have ever been proven for it.

John Bartram wrote to Dr. John Fothergill, whose support Collinson had enlisted:

> We have abundance of medicinal roots, herbs and barks used with success amongst the common people, which are extolled for wonderful specifics, in many infirmities, upon the first discovery made by the Indians on most of them. But when our people take them, not considering age, constitution, season, nor the particular progress, or crises, of the distemper, but expect an immediate cure upon the first or second dose, they are sometimes disappointed. Then it is directly discarded and thrown out of use (especially if the patient grows worse after taking it), and another famous specific gains applause for awhile, then is subject to the other's fate, and another taken into favour.

CIDER PRESS



Lady Petre Pear

Unquestionably this pharmacologic practise would find approval at the hands of antivivisectionists to-day. Several of Bartram's letters to Dr. Fothergill discussed the properties of natural mineral waters, in which subject the doctor was deeply interested.

Although not a physician, at the instance of Benjamin Franklin, Bartram wrote an appendix of American medicinal plants to Thomas Short's "Medicina Britannica." Published in 1751 by Franklin and Hall, this unusual treatise to-day possesses only historical interest. Some of Bartram's observations on the therapeutic indications for the use of certain herbs should be preserved. Spikenard was used as a poultice to fresh wounds or the roots were chewed for the relief of pain in the loins. Collinsonia (horseweed) was recommended for after-pains. Sanguinaria possessed virtue in the treatment of jaundice. Goldenrod in the form of a

decoction was advocated in rattle-snake bites. Gentian was said to be "used with good success for the pleurisy, and in New England, for a vomit. It is a powerful Worker, a little churlish, yet may be a noble Medicine in skilful Hands." Blazing star was characterized as "a great Resister of fermenting Poisons, and the grievous Pains of Bowels, taken in Powder, or the Root bruised and steeped in rum, of which take a Spoonful at once, and as often as need requires, until the Pains remit." Apocinum has been continued until recent years as an emetic or cathartic. Of this drug Bartram remarked that "Peter Kalm saith it is excellent for the hysteric Passion." Boneset tea was granted virtue as an emetic in intermittent fever.

For lobelia or the puke weed Bartram made such remarkable claims that the passage is quoted verbatim:

The learned Peter Kalm (who gained the Knowledge of it from Colonel Johnson, who learned it of the Indians, who after great Rewards bestowed on several of them, revealed the Secret to him) saith, That the Roots of this Plant cureth the Pox much more perfectly and easily than any mercurial Preparations, and is generally used by the Canada Indians for the Cure of themselves, and the French that trade amongst them, tho' deeply infected with it. They take a Handful of the Roots, and boil them in a Quart of Water, and drink the Decoction, beginning with Half a Pint at first, if the Patient be weak, then increase the Dose every Day as he can bear its purging; but if he can't bear it every Day, let him omit it a Day or two, then take to it again, as he finds Occasion, until he is cured: They wash the Ulcer with the Decoction; but if it be deep and rotten, they put some Powder of the inner Bark of the Spruce-tree into it, which helps to dry it up; but if

THE LOWER REACHES OF THE SCHUYLKILL

the Disease is inveterate, they drink the Decoction of Ranunculus Folio Reniformus. An old Sachem told Colonel Johnson of another Shrub, with a red root, from which proceeds several slender branches, eighteen Inches or two Feet long, on which grow Spikes of white Flowers which produce three square black Seed-Pods; the Leaves some of our People drink as Tea, and some smoak it with Tobacco; the Roots of this bruised and boiled, and the Decoction drank, the Sachem said, he preferred to the Lobelia; but the Lobelia seems to be of the most general use, and with extraordinary Success. [Bartram continues,] More particular Directions how to use the Lobelia-Root for the Venereal Disorder, obtained from the Indians, by Colonel Johnson.

After making a Decoction of it, the Patient is to drink about two Gills of it very early in the morning, fasting, the same before dinner, and Bedtime. Add or diminish as you find it agree with the Patient's constitution: the Third Day begin Bathing, and continue it twice a day, until the Sores are well cleansed, and partly healed, then use the Lotion but once a Day till quite well; observing all the Time to use a slender Diet (vegetable Food and small Drink) as in other Courses of Physick, a Salivation excepted. These are the Directions I have had from the Person who gave me the secret.

The crafty hand of Franklin is evident in the lengthy dissertation of this subject and especially in the heading of Bartram's appendix, "Containing Descriptions, Virtues and Uses of Sundry Plants of these Northern Parts of America; and particularly of the newly discovered Indian Cure for the Venereal Disease." Wood and Bache in discussing the use of *Lobelia syphilitica* by the Indians for the treatment of lues dismiss the matter with an opinion that its diuretic action may have influenced the course of gonorrhea. However, no such construction can be placed on Bartram's statement of the healing of ulcers under its administration and local use.

Were John Bartram's scientific position to rest on his medical contributions alone, his title to fame would be rather insecure. His botanical observations were not entirely morphologic, as the following letter bears witness:

I have this spring made several microscopical observations upon the male and female parts in vegetables, to oblige some ingenious botanists in Leyden, who requested that favour of me, which I hope I have performed to their satisfaction, and as a mechanical demonstration of the certainty of this hypothesis, of the different sex, in all plants that have come under my notice. I have made several successful experiments, of joining several species of the same genus, whereby I have obtained curious mixed colours in flowers, never known before; but this requires an accurate observation and judgment to know the precise time.

Benjamin Rush suggested to Bartram the existence of nerves in plants. The latter immediately subscribed to the theory advancing the apparent purposeful movements and adaptations of plants as evidences of intelligence.

Of bird migration Bartram remarked, "For all these wild creatures, of one species, generally seem of one community; and rather than quarrel, will move still a farther distance, where there is more plenty of food—like Abraham and Lot; but most of our domestic animals are more like their masters; every one contends for his own dunghill, and is for driving all off that come to encroach upon them." His position in such matters was invariably substantial. In disagreeing with another observer regarding the characteristics of turtles, he said, "But as for their barking, I believe thy relator barked, instead of the turtle."

Geology was ever a realm of fascinating speculation to him. He once wrote his friend Peter: "My dear worthy friend, thee can't bang me out of the notion that limestone and marble were originally mud, impregnated by a marine salt, which I take to be the original of all our terrestrial salts." Over a century before the famous *Challenger* Expedition, Bartram suggested to John Frederic Gronovius the feasibility of detailed soundings of the seas.

> Query, whether these vast chains of mountains, if these be such, may not be, in part, the cause of the currents in the sea, which our navigators complain so much of; and is it not probable, that there may be various kinds of fish in the great vales, between these ridges, which never appeared, nor can live, near the surface of the water?

The modern geologic survey finds an accurate forecast in a letter of Bartram to Dr. Alexander Garden, of Charleston, South Carolina (March 14, 1756), wherein he proposed to

> bore the ground to great depths, in all the different soils in the several provinces, with an instrument fit for the purpose, about four inches in diameter. The benefit which I shall propose from these trials, is to search for marls, or rich earths, to manure the surface of the poor ground withal. Secondly, to search for all kinds of medicinal earths, sulphurs, bitumens, coal, peat, salts, vitriols, marcasites, flints, as well as metals. Thirdly, to find the various kinds of springs, to know whether they are potable, medicinal, or mechanical. By this method we may compose a curious subterranean map.

Peter Collinson presented certain of Bartram's observations before the Royal Society, which highly commended his efforts. One philosophic communication advancing a theory of the balance between the vegetable and the animal kingdoms won their especial approbation. Collinson set Bartram's mind at rest in the matter of his literary style, by remarking that there was no apology necessary "for thy natural way of expressing thyself is more acceptable, clear and intelligible than a fine set of words and phrases." At times he did criticize John's brevity, feeling that much of the substance of the communication was thereby lost. On the other

hand, Bartram on occasions displayed an excellent command of English and an almost poetic finish in description. His Quaker inhibition was doubtless lifted when the following letter to Dr. Garden was inscribed:

> What charming colours appear in the various tribes, in the regular successions of the vernal and autumnal flowers—these so nobly bold—those so delicately languid! What a glow is enkindled in some, what a gloss shines in others! With what a masterly skill is everyone of the varying tints disposed! Here, they seem to be thrown on with an easy dash of security and freedom; there, they are adjusted by the nicest touches. The verdure of the empalement, or the shadings of the petals, impart new liveliness to the whole, whether they are blended or arranged. Some are intersected with elegant stripes, or studded with radiant spots; others affect to be genteelly powdered, or neatly fringed; others are plain in their aspect, and please with their naked simplicity. Some are arranged in purple; some charm with the virgin's white; others are dashed with crimson; while others are robed in scarlet. Some glitter like silver lace; others shine as if embroidered with gold. Some rise with curious cups, or pendulous bells; some are disposed in spreading umbels; others crowd in spiked clusters; some are dispersed on spreading branches of lofty trees, on dangling catkins; others sit contented on the humble shrub; some seated high on the twining vine, and wafted to and fro; others garnish the prostrate, creeping plant. All these have their particular excellencies; some for the beauty of their flowers; others their sweet scent; many the elegance of foliage, or the goodness of their fruit: some the nourishment that their roots afford us; others please the fancy with their regular growth: some are admired for their odd appearance, and many that offend the taste, smell and sight, too, are of virtue in physic.

Bartram for his part entertained no illusions as to his own shortcomings. "I am glad my friend Dr. Fothergill hath perusal of my notion of the antediluvian impression of marine shells, in our mountain rocks, or any of my rambling observations. I hope, if I can stand the test with his trial, I shall come out like gold well purified. I had rather undergo now a thorough purging—a long fusion, than to have any dross left behind." Contemporary opinion was almost unanimous in acclaiming John Bartram's ability as a botanist. Fothergill spoke of his indefatigable labors and amazing success. The accuracy of his observations was the subject of frequent comment. James Logan, who early stimulated Bartram by word and gifts of botanical texts, remarked that he was "worthier of a heavier purse than fortune had yet allowed him, and had a genius perfectly well turned for botany." Colden spoke of his industry and genius. Dr. John Hope, professor of botany in Edinburgh, wrote "The great reputation which you have just acquired, by many faithful and accurate observations and that most extraordinary thirst of knowledge which has distinguished you, makes me extremely desirous of your correspondence."

A single discordant note is discerned in the attitude of Dr. Alexander Garden. In this instance it is difficult to reconcile Garden's duplicity on the grounds of jealousy; for while his personal communications to Bartram were most cordial, he openly accused him, in a letter to Linnaeus, of misappropriating certain botanical specimens without giving him proper credit. The incident ran thus:

> You tell me you are surprised that I overlooked a new species of the live oak which John Bartram found near Charleston. Let me assure you that John Bartram received from me these very specimens, some of the Phillyrea and many others, from my Hortus Siccus, of which he has, it seems, made a different use from what I apprehended.

Garden on another occasion wrote to John Ellis that Bartram

> knows nothing of the generic character of plants, and can neither class them nor describe them; but I see that, from great natural strength of mind and long practice, he has much acquaintance with specific characters; though this knowledge is rude, inaccurate, indistinct and confused, seldom determining well between species and varieties . . . He tells me that he is appointed King's Botanist in America. Is it really so? Surely John is a worthy man; but yet to give the title of King's Botanist to a man who can scarcely spell, much less make out the characters of any one genus of plants, appears rather hyperbolical. Pray how is this matter? Is he not rather appointed or sent, and paid, for searching out the plants of East and West Florida and for that service only to have a reward and his expenses?

This depreciatory and patronizing tone was entirely foreign to the spirit of such remarks as the following from Dr. Garden to Bartram: "Your letters particularly give me pleasure. They always contain something new and entertaining, on some new-discovered work of God." Or again, "It appears to me to be an age since I have had the pleasure of hearing from you. Pray, write me, and tell me what you are doing; for I know you can't be idle. Tell me what you are discovering; for I know your imagination and genius can't be still. How many wonders of creation do you daily see? Why won't you let me know a few?"

John Bartram's outline of his library to Sir Hans Sloane was evidence of his sincere desire to improve his mind:

> The first authors I read, were Salmon, Culpeper, and Turner. These James Logan gave me . . . Doctor Dillenius sent me Miller's Dictionary, and his own book of Mosses. Lord Petre sent me Miller's Second Part, and the second book of Turner's complete Herbal; and thee kindly obliged me with thy history of Jamaica. Our friend Peter sent me them fine books of Nature Delineated. Catesby sent me his books of Birds, and some books of Physic and Surgery, which was my chief study in my youthful years.

This library has been divided between the Historical Society of Pennsylvania and the Bartram Association through an unfortu-

nate difference of opinion as to its custodianship. The latter group has placed its Bartramana in the department of botany of the University of Pennsylvania.

Benjamin Franklin, a frequent visitor to the Bartram home and a counsellor and friend to John, sought to have the latter prepare a natural history of America. "No one besides is so capable of performing," he urged. Pressing his plea still further, Franklin wrote:

> Although it may not now be suitable for you to make such wide excursions as heretofore, you may yet be very useful to your country, and to mankind, if you sit down quietly at home, digest the knowledge you have acquired, compile and publish the many observations you have made . . . It is true, many people are fond of accounts of old buildings, monuments, etc., but there is a number, who would be much better pleased with such accounts as you could afford them; and for one I confess, that if I could find in any Italian travels, a receipt for Parmesan cheese, it would give me more satisfaction than a transcript of any inscription from any old stone whatever.

Honors from far and near sought out the self-taught botanist in his retreat along the Schuylkill. The historian notes with satisfaction that his neighbors early recognized his ability. The first draft of membership for the proposed American Philosophical Society (1744) included John Bartram's name; and when the plan finally materialized in 1768, his name was continued as the botanical representative in this organization which was through the years to contribute so effectively to the propagation of useful knowledge in America. The Swedish Society of Science conferred its diploma on Bartram. With a gesture of generosity a Society of Gentlemen founded in Edinburgh for the importation of plants and seeds sent Bartram a medal, in lieu of currency, for a shipment which had gone astray. Recognition through a botanical god-child has several times been denied Bartram by the replacement of a proposed designation. The attachment of his name to certain of the mosses is a singular trick of fate, since this field of plant life was the last to be cultivated by him. The genus Bartramia Hedwig with its several species is a common variety of soft green moss carpeting damp shady glades and protected moist niches in rocks. Their capsules, when moist, appear as tiny green apples with the single ruddy cheek marking the operculum of each. This generic characteristic gives license for the common name of apple moss.

It is not to be presumed that Bartram's devotion to botany was achieved through a neglect of his farm or the more material affairs of the world. From a paternal uncle he had inherited some land in Darby Township, Delaware County, Pennsylvania. However with the sheriff sale of the lands, goods and chattels of one Frederick Schobbenhausen in 1728, John Bartram gained possession of

five acres of land in Kingsessing Township along the Schuylkill. This tract formed the nucleus of his garden which was begun about two years later. By commendable industry John Bartram extended his fields to ultimately include about three hundred acres. The construction of retaining walls and drainage ditches reclaimed a considerable acreage of swamp land along the river, while a system of irrigation rendered another portion of soil arable under all atmospheric conditions. Bartram's fair treatment of his negro slaves enabled him to manage his farm advantageously and yet to absent himself for continued periods on botanical excursions. Following the precepts of the Quaker creed, Bartram had freed his slaves, given them a fair wage and clothing and afforded them certain educational and religious advantages. One of these negro freedmen, Harvey, acted as Bartram's steward for many years and in this capacity was a familiar figure in the streets of Philadelphia where he transacted all his master's business. Harvey was buried in the garden on a knoll overlooking the river.

With his own hands, John Bartram quarried and cut the stone with which to build a home on his river tract. He wrote Jared Eliot with all the pride of a skilled craftsman:

> I have split rocks seventeen feet long, and built four houses of hewn stone, split out of the rocks with my own hands. My method is, to bore the rock about six inches deep, having drawn a line from one end to the other, in which I bore holes about a foot asunder, more or less, according to the freeness of the rock; if it be three or four or five feet thick, ten, twelve or sixteen inches deep. The holes should be an inch and a quarter diameter, if the rock be two feet thick; but if it be five or six feet thick, the holes should be an inch and three quarters diameter. There must be provided twice as many iron wedges as holes; and one half of them must be made full as long as the hole is deep, and made round at one end, just fit to drop into the hole; the other half may be made a little longer, and thicker one way, and blunt-pointed. All the holes must have their wedges drove together, one after another, gently, that they may strain all alike. You may hear by their ringing when they strain well. Then, with the sharp end of the sledge, strike hard on the rock, in the line between every wedge, which will crack the rock; then drive the wedges again. It generally opens in a few minutes after the wedges are driven tight. Then, with an iron bar, or long levers, raise them up, and lay the two pieces flat, and bore and split them in what shape and dimensions you please. If the rock is anything free, you may split them as true, almost, as sawn timber; and by this method you may split almost any rock, for you may add what power you please, by boring the holes deeper and closer together.

Standing to-day, his home is a model of substantial Colonial construction. Its lines are quaint and comfortable but scarcely conventional. Ornamentation is not anticipated, but the severe scrolls in the stonework about the windows are an interesting departure. Two further examples of his handiwork in stonecutting are to be found in the garden, namely, the great watering trough

by the house and a cider press at the river's edge. It is probable that the house was constructed in several stages, since a stone in the south end is engraved

John : Ann : Bartram : 1731,

whereas the famous inscription above his study window reads thus:

It is God Alone, Almyty Lord,
The Holy One by Me Ador'd
John Bartram 1770.

The one-story extension on the southern exposure of the old homestead is especially interesting since it was utilized by Bartram as a conservatory.

In person, John Bartram was erect and above middle height. His face was long and its expression animated but controlled by a quiet dignity. No authentic likeness of him has come down to us. His habits were industrious and he found no occasion to lament the lagging hours. Amiable by nature and easy of approach, his family life was exemplary and the Bartram home a byword for Colonial hospitality. His compassionate nature spared even the lowliest insect. "Neither can I behold any of them, that have not done me a manifest injury, in their agonizing, mortal pains, without pity." As has been indicated, he carried his convictions into practice. So being opposed to slavery he freed his Negroes. His creed was inscribed over the door of his greenhouse:

Slave to no sect, who takes no private road,
But looks through Nature, up to Nature's God.

He taught his children to "do good, love mercy and walk humbly before God." In 1758 John Bartram was read out of the Monthly Meeting at Darby because of his liberal religious views. Many years before, he had written to Peter Collinson:

> Indeed I have little respect to apologies and disputes about the ceremonial parts of religion, which often introduce animosities, confusion, and disorders in the mind—and sometimes body too: but, dear Peter, let us worship the one Almighty Power, in sincerity of heart, with resignation to His divine will,—doing to others as we would have them do to us, if we were in their circumstances. Living in love and innocency, we may die in hope.

Whatever the immediate basis for the meeting's action, Bartram continued in attendance and before his death was reinstated in the church.

John, the son of William and Elizabeth Hunt Bartram, was born in Darby Township, Delaware County, Pennsylvania, on March 23, 1699. His grandfather, John Bartram, had emigrated to America from Ashborn, England, in 1682. The family arose from the English soil of Derbyshire; but genealogists have traced their earlier origin to a Norman gentleman who came to England

with William the Conqueror. An ancestor, spelling his name Bertram, served under William at Hastings. The family divided after establishment in England or a second individual of the same name (John Bartram believed them to have been brothers) went to Scotland soon after the landing of the Normans. In any event the name does not appear in England before the Conqueror's period, and thereafter in the various chronicles the name frequently appears in Kent, Sussex and Cumberland. The Bartram coat of arms is thus described:

> Gu. on an escutheon or, betw. eight crosses pattee ar. an anvil ppr. Crest-Issuing out of an antique crown or, a ram's head ppr. Motto—j'avance.

John Bartram was twice married. His first wife was Mary Maris, of Chester Monthly Meeting, whom he married in January, 1723. Two sons were born to this union, but the mother died in 1729. Two years later John Bartram married Ann Mendenhall, of Concord Monthly Meeting, Delaware County. To this marriage nine children were born and Ann survived her husband by six years. John Bartram died on the twenty-second of September, 1777. His last illness was of short duration, but a period of profound suffering before death led him to say, "I want to die." The aged naturalist apparently feared physical incapacity more than death. He lies in an unmarked grave in the Friends' Burial Ground at Darby, Pennsylvania.

Almost his last concern on leaving this world was a fear that his cherished garden would be ravished by the victorious British, at that moment advancing from the Brandywine. The British army, as a fitting tribute to the services of the simple-minded scientist to their native land, spared the garden, which descended to the son John. However, it was William Bartram who inherited his father's love of nature and who maintained the garden in its original state. The farm was kept in the Bartram family for about a hundred years and then passed into the hands of strangers. The earliest of these, Andrew Eastwick, restored the fading glory of the garden in a measure through the efforts of his supervisor, Thomas Meehan. Financial reverses in the Eastwick affairs brought bad days for the historic old garden; and when the Pennsylvania Horticultural Society was unable to avail itself of the offer to sell at a sacrifice, the garden fell into disinterested hands and decay. Unfortunately, botanical vandals stripped it of practically all transportable plants and shrubs, until on its retrieval by the City Council through the efforts of Thomas Meehan in 1891 only a semblance of its former glory remained. Even after this transfer there was no consecutive effort to maintain the grounds in their original form. Progress in the restoration of the garden has been slow, but

the efforts of such forces as the Bartram Association are gradually making themselves felt. The Park Commission has now been given control of this historic spot and more rapid progress may be anticipated.

The present and future generations will miss the lordly cypress which from a sapling obtained in Delaware grew to be the monarch of Bartram's Garden, one hundred and seventy-five feet tall and seven feet in diameter. The Christ thorn, one of a group received from Palestine and sent by Peter Collinson to his friend John, no longer survives. The famous Bartram oak, whose anomalous leaves baffled botanists for many years, is likewise gone. The boxwood which Bartram received from the Earl of Bute still thrives. Tulip trees, buttonwoods, hornbeams and papaws planted by his hand still shade the walks. The yellow-wood is one of the finest specimens in the garden. Of the exotic trees, the ginkgo (Maiden-hair tree) from Japan is one of the most interesting. It is said to have been the first imported into this country. Horse-chestnut trees are found here, but their size would not indicate that they were the original ones which Bartram saw bloom for the first time in America in his own garden. Trumpet vines transplanted by him from the Carolinas grow luxuriantly over the old homestead and adjoining arbors.

Best known among the living ancients in the garden is the Lady Petre pear tree. In 1763, in a letter to Peter Collinson, Bartram said, "The Pear raised from her seed hath borne a number of the finest relished fruit. I think a better is not in the world." To this note Peter replied, "It has been thy patience to wait, but my pleasure to hear of the delicious pears raised from Lady Petre's seed; but she, dear good woman, is gone to rest." For over a century and a half this remarkable tree has borne fruit. Washington and Franklin enjoyed its fine pears and it continues productive. It is significant that one of John Bartram's most prized trees should have survived the storms and neglect of many generations. By this token let us seek to revive the interest in botany and particularly in the study gardens, of which Bartram's was our first and most notable example. Infinite perseverance and industry enabled a single inspired, self-educated man to establish almost two hundred years ago, in a veritable wilderness, a garden famed throughout the civilized world for its remarkable completeness in the native flora of America and for its unusual collection of exotics. Truly the improved paths and channels of communication should to-day make the restoration of this garden spot a much lighter task.

Grateful acknowledgment is made for the continued assistance of my sister, Rena S. Middleton, and Professor John W. Harshberger in the preparation of this biographic sketch.

THE PROGRESS OF SCIENCE

By Dr. EDWIN E. SLOSSON

SCIENCE SERVICE, WASHINGTON

AN INDEX OF OLD AGE

Why does chick or child grow rapidly at first, then gradually slow down and finally stop growing altogether? How does it know when it has got its growth?

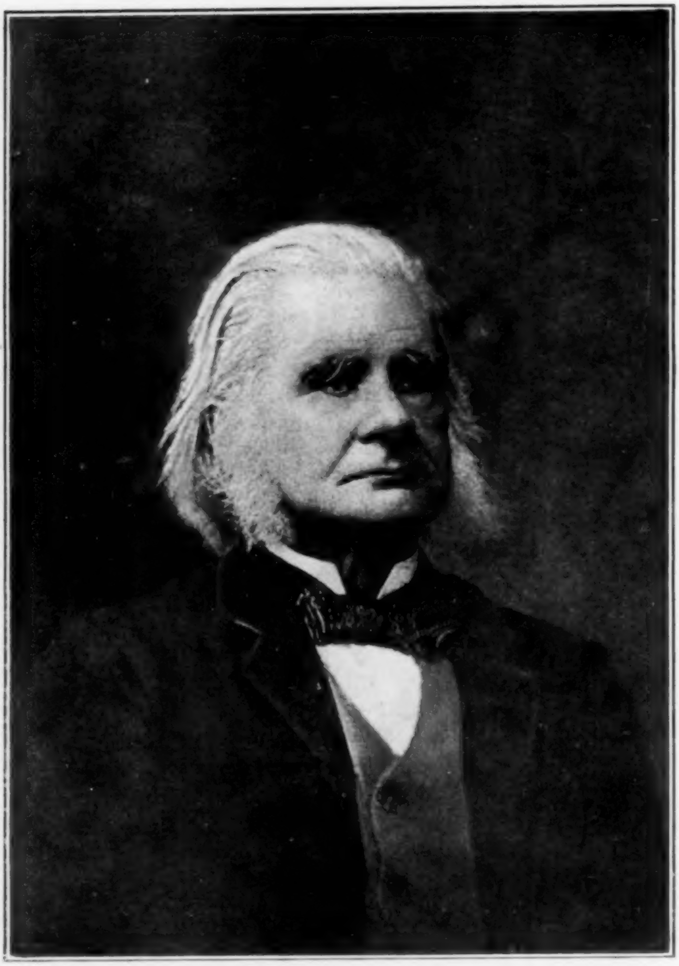
What checks the growth of a leg or a finger when it has reached the proper length? Sometimes of course it does not stop at the right time, and the unfortunate individual gets too tall to fit into a sleeping car berth, or carries through life unwieldy feet or an uncomely nose. But these exceptions only emphasize the rule.

Another mystery of like magnitude. When the individual has reached maturity, and his cells have lost their youthful zeal for expansion and settle down to a quiet life, there may arise an emergency that will set them off again. A cut or burn for instance may destroy a considerable mass of bone or muscle. The neighboring cells, quiescent for years perhaps, start to growing and multiplying at as rapid a rate as when they were young, and within a couple of days have made perceptible progress toward closing the wound. Also why is it that certain peaceful and orderly cells, without any apparent provocation, are suddenly seized with an imperialistic mania and develop a cancer?

We are so accustomed to such occurrences that we think they seem too "natural" to need explanation, yet until recently no one had been able to suggest a reason for them. But a new method of experimentation has been devised by Dr. Alexis Carrel, of the Rockefeller Institute for Medical Research, that promises to throw light upon these old questions. He has found it possible to pick out a few cells from the blood or flesh and grow them in glass flasks, where they can be experimented upon at will. If kept at the normal temperature and duly fed with blood serum and embryonic tissue juice they will thrive and multiply as well as in the body, better in fact, for they do not die of old age, but live on indefinitely. He started the artificial cultivation of a minute bit of cartilage from the heart of an unhatched chicken over twelve years ago, and it is growing yet, long after the fowl would have died if it had hatched.

Such cartilaginous tissue can not live on serum alone. Apparently its protein has to be prepared for it by certain growth-promoting agencies that he calls "trephones," that is feeders. They are produced by the white blood corpuscles and certain glandular secretions, and they decrease with age. But besides this the serum contains some sort of substance that works the other way. It restrains or prevents the multiplication of cells and so inhibits growth. The amount of this inhibiting factor in the blood increases with advancing age, rapidly at first and then more slowly.

This discovery affords a way of measuring the age of an animal by observing the effect of its blood serum on the cells under cultivation in the flasks. When, for instance, the cells were supplied with serum from a hen six weeks old they lived forty-six days. In serum from a three-



THOMAS HENRY HUXLEY

Portrait from the photograph by Mayall taken in 1893 and printed in the "Life and Letters" by Leonard Huxley, published in New York by D. Appleton, 1900. The centenary of Huxley's birth was celebrated on May 4.

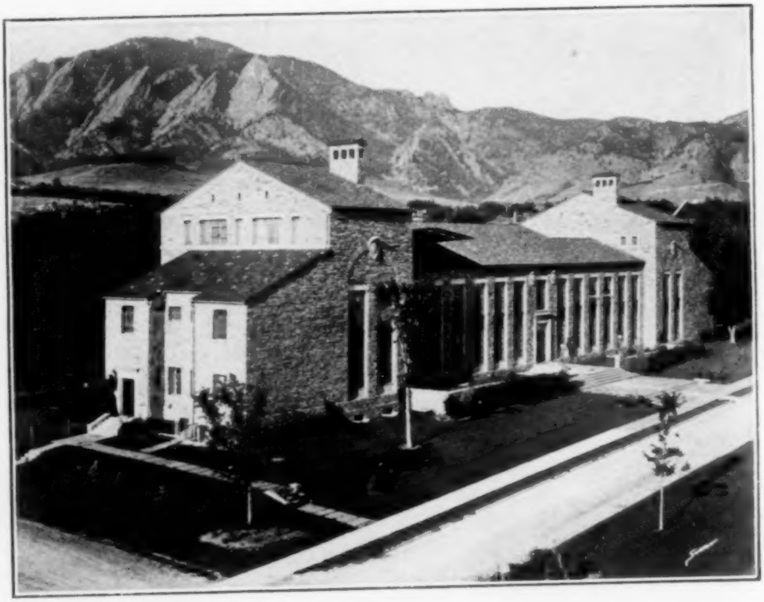
months old hen they lived thirty days. In serum from a three-year old hen they lived fifteen days, and in serum from a nine-year old hen the cells survived only four to six days. If this test could be sufficiently simplified we might be able to ascertain with accuracy the age of a spring chicken, instead of having to take the dealer's word for it.

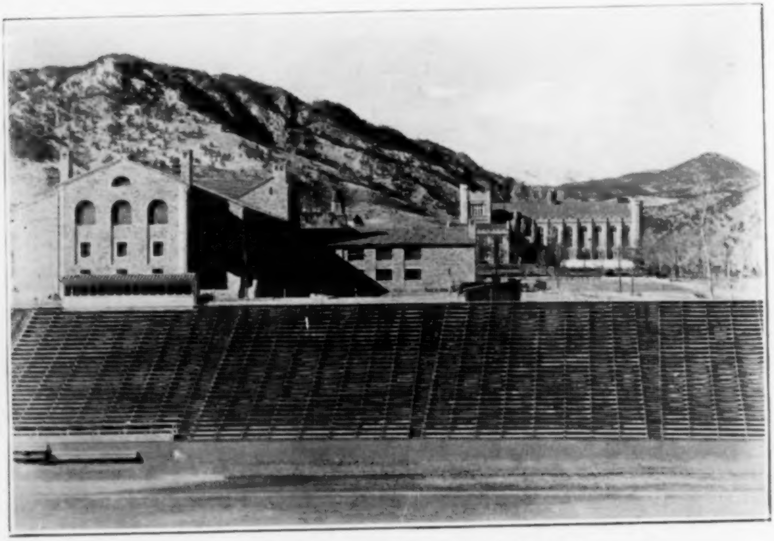
Experiments with the blood of dogs gave the same results. The serum from a dog eight years old restrained the growth of the cells ten times as much as serum from a two weeks old pup.

Whether the method can be applied to human beings remains yet to be

FROM AN AUTOGRAPH LETTER BY THOMAS H. HUXLEY

Part of a letter addressed to Sir Joseph D. Hooker on February 14, 1895, referring to the recent discovery that had been made by Dubois in Java. From the "Life and Letters."





THE UNIVERSITY OF COLORADO

Boulder, Colorado, where the Southwestern Division of the American Association for the Advancement of Science held its annual meeting in June. Above is the arts and science building with the foothills of the Rocky Mountains in the background. Below is the new gymnasium and the Macky auditorium with the snow-covered Arapahoe peaks in the distance.

REED COLLEGE

Portland, Oregon, where the Pacific Division of the American Association for the Advancement of Science held its annual meeting in June. Above is a view of the arts building. Below are the dormitories and commons.

determined. If it can be we may be able some day to determine not only how old a person actually is, but why. And if the growth-promoting and the growth-restraining factors can be identified and independently prepared it may be possible to regulate their balance and restore it when it is disturbed.

LOOK OUT FOR "A"

WE are beginning to learn our ABC's in the field of vitamins and even the groceryman can tell us which of his eatables are richest in those elusive but essential factors that the chemist has not yet been able to extract and identify.

Yet it is only twelve years since the first one was found, or to speak more accurately, found necessary. This is the one called "vitamin A" and its importance was discovered in the course of feeding experiments when it was found, contrary to what was then assumed, that all fats were not quite the same in food value, that lard was not so good as butter, and that olive oil was not so good as fish oil, and that white corn was not so good as yellow corn in promoting growth if they were the only source of fat in the nation. That is, all the fats and oils are almost equally edible and nutritious and digestible and useful in furnishing fuel to run the engines of the body, but some of them, and only some of them, have in them besides a little of something else that the body must have for growth and health.

A new series of very carefully conducted experiments by Professor H. C. Sherman, of Columbia, has shown that vitamin A is also necessary for the production of offspring. He matched twin white rats of the same litter and sex. One set was fed whole milk powder, the other skimmed milk powder. In other experiments one set was fed butter fat and the other lard or coconut fat. In other respects the rations were the same, mostly ground whole wheat. The first set therefore lived on a diet containing an ample supply of vitamin A, while the other lot had a ration that was poor in vitamin A.

The difference was striking. Both lots of the rats grew up to maturity in about the same time, but the rats that had plenty of A grew bigger and lived longer and produced more young. The rats on the low-vitamin diet weighed only 69 per cent. as much as their better fed brethren. The rats that had plenty of A lived more than twice as long as the average.

But the most striking difference was in the breeding records. The 17 females on the diets richer in vitamin A had a total of 477 young of which they raised 264. The 17 females on the diets poorer in vitamin A gave birth to only 31, and none of these lived longer than two days. Both sets had plenty of the recently discovered "fertility vitamin" X or E, since wheat germ was in both rations.

Another significant fact is that the rats on the vitamin-poor diet showed a greater "susceptibility to infection and particularly a tendency to break down with lung disease at an age corresponding to that at which pulmonary tuberculosis so often develops in young men and women."

Animals that have lived on a liberal diet will store up enough vitamin A to last a long time if they are deprived of it. Nine tenths of this is laid up in the liver. But it does not appear that any animal has the power to make this vitamin out of any foods that do not contain it. It is most abundant in cod-liver oil, butter, whole milk, liver, herring, egg yolk,

alfalfa, clover, cabbage, carrots, sweet potatoes and spinach. It is practically absent from Irish potatoes, lean meat, malt extract, wheat bran, grapes, olive oil, corn oil, lard, tallow and yeast cakes. We do not need much of A, but we need that little much.

LEGISLATIVE ORTHODOXY

In 1899 the legislature of Indiana undertook to establish a new value of Pi, that indispensable but inconvenient number which represents the ratio of the circumference of a circle to its diameter. Certainly this needs reforming as much as anything in the world. It begins 3.141592 . . . and goes like that forever; at least nobody has got to an end of the decimal, although mathematicians have worked it out to more than 700 places.

So when an Indianian ex-teacher offered to give the state the right to use free in the state schools his proof that the true value of Pi was an even 4, the legislators jumped at the chance, and a bill establishing that value was introduced and passed unanimously through three readings in the lower house and two in the upper. Of course, like politicians generally, they never thought of seeking expert advice, so Purdue and the state university were not consulted; but a member of the Indiana Academy of Sciences, C. A. Waldo, coming to see after the academy appropriation, found the lower house calling the roll on the final reading of the Pi bill. That evening he visited such senators as he could see and gave them a lesson in elementary geometry; consequently, it was defeated on its third and final reading in the senate.

If it had not been for this accidental intervention the teachers of Indiana would have had to teach a false formula to their students, and what would have happened to the trains that went around the curves laid out on this figure, and to the domes of buildings and the arches of bridges, and machinery made in the shops, so calculated, is appalling to contemplate. The Egyptians 1700 years before Christ had figured out Pi as 3.16, so that from yonder pyramids thirty-six centuries would have looked down upon Indiana. I do not know what penalty was imposed by the Indiana act upon a teacher whose students when they measured a circle got an illegal result. A statute of Oxford University in 1583 provided that any master or bachelor who deviated from the doctrine of Aristotle on any point should pay a fine of five shillings for each such offense. I do not know whether the rule has been repealed yet or not. Probably not. Oxford rarely repeals. But while it was enforced a teacher could not often afford the luxury of mentioning that the earth moves. A school prospectus of later times announces that students will be taught either that the sun moves or the earth moves, according to which parents prefer. Perhaps our private schools will soon be inserting in their application blanks; "Please specify whether you want your child taught the monkey or the Moses theory."

Heresy comes higher than it used to. Instead of five shillings a teacher in Tennessee may be fined five hundred dollars for each offense of teaching "that man has descended from a lower order of animals." At that rate, a teacher might lose his year's salary for a slip of the tongue, or for pointing inadvertently to a fossil bed, from which students might draw an illicit inference.

—*Courtesy of the New York World*

THE LITTLE RED SCHOOLHOUSE IN TENNESSEE

It is amusing to see that the newspapers in referring to the law of Tennessee and other states requiring that the reading of Scriptures in school shall be "without comment," call it "Puritanism." On the contrary, our New England ancestors insisted that the Scriptures should not be read without comment even in church. They denounced such a practice as "dumb reading," and condemned it as savoring of the ritualism from which they had revolted. The minister was required to expound the chapter passage by passage as he read, lest it should be heard unheedingly or misunderstood. When later some of the city churches began to introduce the custom of reading the Bible without explanation it was strongly opposed as a perversion of the faith. A good old orthodox Puritan living to-day would probably take his children out of a school where the Bible was read without comment, from conscientious objections.